DISSERTATION ON

MICROSURGICAL ANATOMY OF
ANTERIOR CEREBRAL ARTERY
A1-ACOM-A2 COMPLEX

M.Ch., Degree Examination

Branch 11-Neurosurgery

THE TAMILNADU DR.M.G.R. MEDICAL UNIVERSITY

CHENNAI

FEBRUARY-2007

CERTIFICATE

This is to certify that the dissertation entitled "**MICROSURGICAL ANATOMY OF ANTERIOR CEREBRAL ARTERY A1-Acom-A2 COMPLEX**" was done under our supervision and is the bonafide work of **Dr.G.Murugesan**. It is submitted in partial fulfillment for the M.Ch. Neurosurgery Examination.

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ACKNOWLEDGEMENT

I immensely thank **Prof.R.NANDAKUMAR**, Professor of Neurosurgery in allowing me to Conduct this study. I thank him for his expert guidance. He was a constant source of encouragement throughout the study and ensured the successful completion of the study.

I thank **THE DEAN,** Government General Hospital for permitting me to use the case material for the study.

I Acknowledge **Prof. A.R.JAGATHRAMAN, Prof. N. KARTHIKEYAN, Prof. A. KALIAPERUMAL, Prof. ARUN KUMAR,** Additional Professors of Neuro Surgery, Govt. General Hospital, **Prof. V.G.RAMESH,** Professor of Neurosurgery, Chengelpet Medical College, **Prof. K.DEIVEEGAN**, Professor Neurosurgery,Govt. Stanely Medical College, **Prof. R.VALLINAYAGAM,** Professor and Director of institute of Forensic Medicine **(Retd) Prof. M.MOHAN SAMPATHKUMAR**, and **(Redt) Prof. K.R.SURESHBABU**, for their help and encouragement during the study period.

I thank all the Assistant Professors of Neurosurgery and fellow post graduates, Institute of Neurology and Institute of Forensic Medicine Government General Hospital in helping me complete the study.

I thank the staff, Institute of Neurology and Government General Hospital, Chennai and all others who have helped me in completing the study.

CONTENT

AIM OF THE STUDY

To study the microsurgical anatomy and variations of the anterior cerebral artery A1-ACOM-A2 Complex in our population and to discuss its implication with respect to anatomical,pathophysiological and neurosurgical perspectives.

INTRODUCTION

Microneurosurgery, has evolved, over the years with the better understanding of the normal and myriads of variation that occur in the miniature structures of the brain. Micro dissection of cadaver specimens is the base on which our knowledge of the intricate of the human brain is built.

Neurovascular anatomy of the brain, is the most complex of all and the variations encountered are as distinct as a finger print. Most neurovascular surgeons in the premicroscopic era, were handicapped with a poor knowledge of the minute vessels that supplied the vital regions of the brain. They were not able to explain the unexpected deficits patient suffered after apparently uneventful surgery.

The advent of microneurosurgery and the knowledge of the tiny perforating vessels and their arrangements along the base of the brain has made much awaited changes in the outcome of patients undergoing surgery in relation to neuro vascular structures.

Anterior Cerebral Artery is the complex arterial system and anterior half of circle of willis of the brain. Thorough knowledge of the microsurgical anatomy and the anatomical variations are mandatory for the neurosurgeons to adopt the best possible technique to avoid disaster during surgery and to have good functional outcome in patients.

Various authors have studied, the ACA A1-ACOM-A2 in detail and have explained their variations in other countries. No large study of this nature has been done in our population, though few small Indian studies have been done. This study is done to improve the knowledge of the variations in micro surgical anatomy of anterior cerebral artery in our population.

ANTERIOR CEREBRAL ARTERY

The ACA, the smaller of the two terminal branches of the internal carotid artery arises at the medial end of the sylvian fissure lateral to the optic chiasm and below the anterior perforated substance. It course anteromedially above the optic nerve or chiasm and below the medial olfactory striate to enter the interhemispheric fissure. Near its entrance into the fissure it is joined by the opposite ACA by the AComA, and ascends in front of the lamina terminalis to pass into the longitudinal fissure between the cerebral hemispheres.

The arteries from each side are typically not side by side as they enter the interhemispheric fissure and ascend in front of the lamina terminalis rather one distal ACA lies in the concavity if the other. Above the lamina terminalis, the arteries make a smooth curve around the genu of the corpus callosum and then pass backward above the corpus callosum in the pericallosal cistern. In their midcourse, one or both ACAs frequently turns away from the corpus callosum only to dip sharply back towards it. After giving rise to the cortical branches, the ACA continues around the splenium of the corpus callosum as a fine vessel,often tortuous, and terminates in the choroid plexus in the roof of the third ventricle. The posterior extent of the ACA depends on the extent of supply of the PCA and its splenial branches.

The ACA often has four convex curves as viewed laterally: The convexity is posterosuperior between its orgin and the AcomA, anteroventral as its turns into the interhemispheric fissure, posterosuperior at the junction of the rostrum and genu of the corpus callosum. Branches of the distal ACA are exposed in surgical approaches to the sellar and chiasmatic regions, third and lateral ventricles, falx and parasagittal areas, and even in approaches to the medial parieto-occipital and pineal regions.

Segments

The ACA is divided at the AcomA into two parts,proximal(pre communicating) and distal(post-communicating), The proximal part, extending from the origin to the AcomA ,constitutes the A1 segment. The distal part is formed by the A2 (infracallosal), A3(precallosal), A4(supracallosal) and A5(posterocallosal) segments. The relationships of the four distal segments are reviewed below.

A1 Segment and the anterior communicating arteries

The A1 courses above the optic chiasm or nerves to join the AComA. The junction of AComA with the right and left A1 is usually above the chiasm rather than above the optic nerves.

A normal ACA-AComA is one in which an AComA connects A1s of nearly equal size, and both A1s and the AComA are of sufficient size, to allow circulation between the two carotid arteries and through the anterior circle of Willis.

There is a direct correlation between the differences in the size of the right and left A1s and the size of the AComA. As the difference in diameter between the A1s increases, so does the size of the AComA. Thus, a large AcomA is often associated with a significant difference in diameter between the right and left A1.

This correlation between the sizes of the A1s permits a rough estimate of the size of the AComA, even though the artery is not visualized, because it is the most difficult part of the circle of Willis to define on cerebral angiography.

Another difficulty in angiographically defining the AComA is that it is frequently not oriented in a strictly transverse plane. The length of the AComA is oriented in an oblique or straight anterior-posterior plane if one ACA passes between the hemispheres behind the other ACA. The ACAs are side by side as they pass between the cerebral hemisphere in approximately one in five in hemispheres, and the left is anterior to the right more often than the right is anterior to the left.

One AComA was present in 60%, two in 30%, and three in 10% of the brains. Double AComAs can take a variety of forms; one is simply a hole in the middle of a broad or triangular artery separating arteries.

An infrequent finding is duplication of a portion of the A1.Another infrequent anomaly consists of a third or median ACA arising from the AComA. The median artery courses upwards and backwards above the corpus callosum. It frequently divides opposite the paracentral lobule and gives branches to the paracentral lobules of both sides. In such cases, the ACAs proper are usually small and supply the anteromedial surfaces of the hemispheres.

Recurrent Artery

The recurrent branch of the ACAs first described by Heubner in 1874, is unique among arteries in that it doubles back on its parent ACA and passes above the carotid bifurcation and MCA into the medial part of the sylvian fissure before entering the anterior perforated substance. It pursues a long ,redundant path to the anterior perforated substance, it is often closely applied to the superior or posterior aspect of the A1.

In Rhoton studies, there was a single recurrent artery in 28% of the hemispheres, two in 48%, and three or four in 24%. The recurrent branch usually arises from the distal A1 or from the proximal part of the ACA segment just distal to the AComA, referred to as the A2; however it may emerge at any point along the A1.

The recurrent arteries arising near the AComA usually arise from the lateral side of the junction of the A1 and A2 at a right angle to the parent vessel. They may originate either in common with or gives rise to the frontopolar artery.

The recurrent artery may enter the anterior perforated substance as a single stem or divide into many branches (average four). Of the total branches, approximately 40% terminate in the anterior perforated substance medial to the origin of the ACA, and 40% terminate lateral to the ACA origin. The remaining branches pass to the inferior surface of the frontal lobe adjacent to the anterior part of the caudate nucleus, anterior third of the putamen, anterior part of the outer segment of the globus pallidus, anteroinferior portion of the anterior limb of the internal capsule, and the uncinate fasciculus, and less commonly, the anterior hypothalamus.The hypothalamic supply is less than from the A1.

Basal perforating Branches

The A1 and A2 and the AComA give rise to numerous basal perforating arteries. An average of 8 basal perforators exclusive of Heubner's artery arise from each A1. The lateral half of A1 branches terminates in descending order of frequency, in the anterior perforated substance, the dorsal surface of the optic chiasm or the suprachiasmatic portion of the hypothalamus, the optic tract, dorsal surface of the optic nerve and the sylvian fissure between cerebral hemispheres and the lower surface of the frontal lobe.

The A1, excluding the recurrent artery and the A2, most consistently supplies the chiasm and anterior third ventricle and hypothalamic area, but only inconsistently supplies the caudate and globus pallidus. Heubner's artery, by contrast, provides a rich supply to the caudate and adjacent internal capsule, but much less to the hypothalamus than the A1.

The AComA also frequently gives rise to perforating arteries that terminate in the superior surface of the optic chiasm and above the chiasm in the anterior hypothalamus, The AComA is frequently the site of orgin of one or two, but as many as four branches that terminate, in descending order of frequency, in the suprachiasmatic area, dorsal surface of the AComA.

Distal Part

The distal or postcommunicating part of the ACA begins at the AcomA and extends around the corpus callosum to its termination. The distal ACA is divided into four segments. The A2 (infracallosal) segment begin at the AComA, passes anterior to the lamina terminalis, and terminates at the junction of the rostrum and genu of the corpus callosum. The A3 (precallosal) segment extends around the genu of the corpus callosum and terminates where the artery turns sharply posterior above the genu.

The A4 (supracallosal) and A5 (postcallosal) segments are located above the corpus callosum and are separated into an anterior(A4) and posterior(A5) portion by a point bisected in the lateral view close behind the coronal suture.

The Pericallosal Artery

The pericallocal artery is the portion of the ACA distal to the AComA around and on or near the corpus callosum. The artery formed by the bifurcation near the genu of the corpus callosum into the pericallosal and callosomarginal arteries.

The Callosomarginal Artery

The callosomarginal artery, the largest branch of the pericallosal artery,is defined as the artery that courses in or near the cingulate sulcus and gives rise to two or more major cortical branches. The callosomarginal artery is present in 80% of hemispheres.

The size of the pericallosal artery distal to the callosomarginal origin varies inversely with the size of the callosomarginal artery.

Distal ACA Branches

The distal ACA gives origin to two types of branches: 1)basal perforating branches to the basal structures including the optic chiasm, suprachiasmatic area, lamina terminalis, and anterior hypothalamus, structures located below the rostrum of the corpus callosum and 2) cerebral branches divided into cortical branches to the deep white and gray matter and the corpus callosum.

Basal Perforating Branches

The A2 segment typically gives rise to four are five(range,0-10) basal perforating branches that supply the anterior hypothalamus, septum pellucidum, medial portion of the anterior commissure, pillars of the fornix, anteroinferior part of the striatum . They commonly take a direct course from the A2 segment to anterior diencephalons.

Cortical Branches

The cortical branches supply the cortex and adjacent white matter of the medial surface from the frontal pole to the parietal lobe where they intermingle with branches of the PCA. On the basal surface, the ACA supplies the medial part of the orbital gyrus, the gyrus rectus and the olfactory bulb and tract on the lateral surface; the ACA supplies the area of the superior frontal gyrus and the superior parts of the precentral, central and postcentral gyri.

The band of lateral cortex supplied by the ACA is wider anteriorly,often extending beyond the superior frontal sulcus, and narrows progressively posteriorly. The distal ACA on one side sends branches to the contralateral hemisphere in nearly two-thirds of the brains.

Eight cortical branches are typically encountered. They are orbitofrontal,frontopolar, internal frontal,paracentral,and the parietal arteries; the internal frontal group is divided into the anterior, middle, and posterior frontal arteries, and the parietal group is divided into superior and inferior parietal arteries .the smallest cortical branches is the orbitofrontal artery and the largest is the posterior internal frontal artery. The frontopolar and orbitofrontal artries are present in nearly all hemispheres; the least frequent branch is the inferior parietal artery, present approximately in two-thirds of the hemisphere. The most frequent ACA segment of origin of the cortical branches is as follows: orbitofrontal and frontopolar arteries, A2; the anterior and middle internal frontal and callosomarginal arteries,A3; The paracentral artery A4; and the superior and inferior parietal arteries A5. The posterior internal frontal artery arises with approximately equal frequency from A3 ,A4, and the callosomarginal artery. All of the cortical branches arise from the pericallosal artery more frequently than they do from the callosomarginal. Of the major cortical branches, one of the internal frontal arteries are the paracentral artery arises most frequently from the callosomarginal.

The cortical branches that arise most frequently from the callosomarginal artery is the middle internal frontal artery. Of the callosomarginal arteries present in our study, 50% give rise to two major cortical branches ,32% give rise to three major cortical branches,16% give rise to 4,and, in one hemisphere,five of the eight major cortical branches from the callosomarginal artery.

Orbitofrontal Atery

This artery,the first cortical branch of the distal ACA ,is present in nearly all hemispheres. It commonly arises from the A2 , but may also arise as a common trunk with the frontopolar artery. It may uncommonly arise from the A1 segment just proximal to the AComA from its origin,which passes down and forward towards the floor of the anterior cranial fossa to reach the level of the palnum sphenoidale. It supplies the gyrus rectus, olfactory bulb, and tract, and the medial part of the orbital surface of the frontal lobe.

Fronto polar artery

The next cortical branch, the frontopolarartery, arises from the A2 segment of the pericallosal artery in 90% of hemispheres and from the callosomarginal artery in 10%.From origin it passes anteriorly along the medial surface of the hemisphere towards the frontal pole.It crosses subfrontal sulcus and supplies portions of the medial and lateral surfaces of the frontal pole.

Internal Frontal Arteries

The internal frontal arteries supply the medial and lateral surfaces of the superior frontal gyrus as far posteriorly as the paracentral lobule(6). They most commonly arise from the A3 segment of the pericallossal artery or from the callosomarginal artery.

The posterior internal frontal artery arises with nearly equal frequency from the A3 , A4 and the callosomarginal artery and courses upward to the singulate sulcus, then backward for a short distance before turning superiorly to terminate in the uppermost limit of the precentral fissure it supplies the posterior third of the superior frontal gyrus and part of the cingulated gyrus. Its branches frequently reach the anterior portion of the paracentral lobule.

Paracentral artery

This branch usually arises from the A4 or the callosomarginal artery approximately midway between the genu and splenium or the corpus callosum. It supplies a portion of the premotor, motor and somatic sensory areas. It may represent the terminal portion of the ACA.

Parietal Arteries

The parietal arteries, named the superior or interior parietal arteries,supply the ACA distribution posterior to the paracentral lobule the superior parietal arteries arises from the A4 or A5 and from the callosomarginal artery and supply the superior portion of the precuneus.

Convexity Branches

There are large areas of the lateral cortical distribution of the ACA. There is a good chance of finding a vessel of sufficient diameter for a bypass anastamosis with a frontal branch of the superficial temporal artery. The area offering the best chance of finding an adequate ACA branch on the lateral surface was determined by drawing a circumferential line on the outer circumference of the hemisphere beginning at the sylvian fissure and continuing around the frontal pole and over the superior hemisphere margin towards the occipital pole the minimum diameter needed for an anastomosis is usually considered to be 0.8mm(27). And identical line was drawn to cm inside the circumferential line. The largest percentage of ACA branches crossing these lines was located on the anterior portion of the hemisphere between the 5cm and 15cm points and the circumferential line.

Callosal Branches

The ACA is the principal artery supplying the corpus calosum. The pericallosal artery sends branches to the rostrum,genu,body and splenium and often passes inferiorly around the splenium. The terminal pericallosal branches are joined posteriorly by the splenial branches of the PCA.

Anomalies

Anomalies of the distal ACA, including triplication of the postcommunical segment, failure of pairing of the distal ACA, and bihemisphere branches, are found in approximately 50% brain(2). bihemispheric branch is one that divide distal to the AcomA and provides the major supply to the medial surface of both hemisphere. In the presence of such an anomalies occlusion of one ACA. Distal to the AComA may produce bilateral cerebral injury similar to that produced by blocking both ACAs. This distal ACA on oneside send branches to the contralateral hemisphere in nearly two-thirds of brains. However, most supply only a small area on the medial surface of the contralateral hemisphere. And infrequent anomalies is one in which the ACA distal to the A1 segment and unpaired and a single distal ACA divides to supply both hemispheres.

REVIEW OF LITERATURE

The study of anatomy of anterior cerebral artery complex can broadly be considered as those studies done in the premicroscopic surgery era and microscopic surgery era. In the premicroscopic surgery era done by GRAYS. Anterior cerebral artery is the smaller artery terminal branch of internal carotid artery, starts at medial end of the stem of lateral cerebral sulcus and passes anteromedially above the optic nerve to the longitudinal fissure, where it connects with its fellow by a shorts transverse anterior communicating artery. The two arteries thence travel together in the fissure, curving round the genu of corpus callosum and back along its upper surface to its posterior end , where they anastamose with posterior cerebral arteries. Occasionally they are a single vessel. There are central and cortical branches.

The anterior communicating [Acom] artery , with an average length of 4 mm , connects anterior cerebral arteries across the anterior end of the longitudinal fissure; it may be double. It has a few anteromedial central branches, these are the three to 13 number in supply the optic chiasm, lamina terminalis, hypothalamus,parolfactory areas, fornix(anterior columns) and cingulated gyrus.

Central branches arise from the commencement of the anterior cerebral, entering the anterior perforated substance and lamina terminalis to supply the rostrum of the corpus callosum, septum pellucidum, anterior part of the putamen of the lentiform nucleus and head of the caudate nucleus. Cortical branches are named by distribution; two or three orbital branches ramify on the frontal lobe s orbital surface , supplying the olfactory lobe , gyrus rectus and medial orbital gyrus; frontal branches supply the corpus callosum, cingulated gyrus, medial frontal gyrus and paracentral lobule , sending twigs over the hemisphere s supero medial border to the superior and middle frontal gyri and upper part of pre central gyrus(including the leg area of motor cortex) parietal branches supply the precuneus and adjacent lateral surface.

The advent of microsurgical techniques in cerebro vascular surgery ,has interested many like **Charter et al** [1976], **Grant et al** [1980], **Gibo et al** [1981], **Umnasky et al** [1984] **Prtlmutter D, et al, Albert L,Rhoton et al** [1982] **M.G. Yasargil** [1984] to do research on microsurgical anatomy of cerebral vasculature.

Perlmutter D, et al states that(J Neurosurgery 1978 aug)states that the most frequent site of origin of the cortical branches was as follows: orbitofrontal and frontopolar arteries, A2;The anterior and middle internal frontal and callosomarginal arteries, A3;The paracentral artery, A4; and the superior and inferior parietal arteries, A5; The posterior internal frontal artery arose with approximately equal frequency from A3 and A4 and callosomarginal artery . All the cortical branches arose more frequency from the pericallosal than the callosomarginal artery. Of the major cortical branches, the internal frontal and paracentral arteries arose most frequently from the callosamarginal artery . The distal ACA of one hemisphere sent branches to the contralateral hemisphere in 64% of brains.

Perlmutter D et al (J neuro surgery 1976 sep) states that it arose from the A-2 segment of the anterior cerebral artery(ACA) in 78% and most commonly terminated in the area area of the anterior perforated substance ,and lateral to it in the Sylvian fissure. The proximal half of the A-1 segment was a richer source of perforating arteries than the distal half.

Perlmutter D et al states that(I Neurl Res,1980) the anterior communicating artery frequently gives rise to perforating arteries that terminates in the superior surface of the optic chiasm and anterior hypothalamus.

The first 5mm of the distal anterior cerebral artery (A2) had perforating branches penetrating the brain at the gyrus rectus and olfactory sulcus. The recurrent artery of Heubner originated from the A2 segment of the anterior cerebral artery in 57% of the cases, from the anterior cerebral artery-anterior communicating artery junction in 35%, and from the A1 segment in 8%. The depth of the interhemisphere fissure at the genu was 36mm.

M.G. Yasargil et al, [1984] state that The size of the anterior cerebral artery is usually 1.0-3.0 mm but hypoplastic (< 1.0mm) and very hypoplastic (<0.5mm) arteries are frequently seen. As with most small perforating arteries, there is commonly (46%) a stem vessel that originates from the proximal anterior cerebral artery. The anterior communicating artery is commonly between 0.1-3 mm long. Its normal caliber is between 1.0-3.0 mm, but hypoplstic (0.5-1.0 mm). The size of the recurrent artery of Heubener varies from 0.2-2.9 mm. From its origin the artery is contained within the lamina terminalis cistern. It usually runs anterior to the A_1 segment (60%), but also frequently courses postero-superior to it (40%).

Aydin IH,Onder A et al states that Heubner's artery variations in anterior communicating artery aneurysms,the artery of Heubner originated from the junction of the A1 and A2 segments of the anterior cerebral artery(ACA) in 58%, from the A2 segments of ACA in 23%, and from the A1 segment of ACA 4%. It was asymmetrically taking off in 13% and hypoplastic in 2% of the cases. Three types of recurrent artery courses : The type one or the superior couse was seen in 71%, the type second or the anterior course was found in 25% and type third or the posterior course was recorded in 4%.

Emel AVCI, et al states that(2003) forty-nine (64%) of a total of 77 RAHs arose from the A2 segment . The OFA always arose from the A2 segment,was consistently the smallest branch,and coursed to the gyrus rectus,olfactory tract,and olfactory bulb medial subfrontal region. The mean distance between the AcoA and the OFA was 5.96mm. The FPA arose from the A2 segment in 95% of the specimens,and course to the medial subfrontal region. The mean distance between the AcoA and the FPA was 14.6mm. The RAH,OFA, and the FPA are three branches that arise from the ACA near the AcoA complex. These vessels have similar diameters,but can be distinguished by their final destination.

Esra Gurdal et al states that Neuroanatomy(2004) two unusual variations of the anterior communicating artery(AcoA)were observed . In the first case AcoA was duplicated with a fenestrated anterior cerebral artery(ACA). In the second case, an oblique AcoA was present. Further two branches of the oblique AcoA were joined the right ACA.

Robert M Crowell, M.D et alstates that ACom arterial diameter ranged from 0.8 to 2.3 mm, with tengths of 5 to 10 mm. Branches of the anterior communicating artery were found in every case (range 3-13 average 5.4) , but atleast one large (250-1000) was invariably present. Small ventral branches ramified on the optic chiasm. Small and large dorsal branches distributed themselves to lamina terminalis,hypothalamus,parolfactory areas,coloumns of fornix and corpus callosum. Injury to these vessels caused by aneurysmal rupture or surgical manipulation may lead to serious clinical deficits.

Kurtis I et al states that nonsaccular aneursysms of the azygos anterior cerebral artery Azygos ACA aneurysms accounted for 0.5% of all treated lesions and 1.7% of all ACA and anterior communicating artery aneurysms. One lesion in this series was located proximally at the azygos ACA origin, and three were located distally. All four aneurysms were large (>10mm in diameter), and two were thrombotic. All aneurysms were treated with microsurgical clip occlusion.

Azygos ACA ancurysms are rare, and may have unusual nonsacclur anatomy . The nonsaccular morphology of these aneurysms may render them unsuitable for endovascular coil placement, and may complicate their microsurgical management.

Francis Cassot et al states that AcoA diameter strongly modulates the effects of ICA lesions on cerebral hemodynamics. Some proposals for endarterectomy indications can be derived from this study.

Gomus et al states that recurrent artery of Heubner arises from the A2 Segment Of Aca in 57% of the brains , 35% from ACOM artery junction , 8% from A1 segment.

Serizuwa T et al states that 60 % of ACOM has variations like fenestrated ACOM , triple ACA , Azygos ACA.

MATERIALS AND METHODS

This study was conducted in **MADRAS INSTITUTE OF NEUROLOGY** and in the autopsy theatre of the **Institute of forensic medicine**, Madras Medical College and Government General Hospital Chennai from may 2003 to july 2006.

A total number of 40 brains were dissected. Brains of head injury patients, intra cranial pathology patients were excluded from the study. The brains of only those who died due to other causes were taken up for study.

MATERIALS USED FOR DISSECTION

40 fresh adult cadavers of both sexes were examined in the autopsy theatre of the Institute of forensic medicine, Madras Medical College and Government General Hospital Chennai.

- Entire dissection was carried out under 4x magnification using Carl zeiss magnifying loupe.

- Standard verniar caliper with accuracy of 0.2 mm was used for measurements

- Other Instruments used are Toothed forceps, needle, syringe, cannula poster colour, cotton, scissors, 11 blade knife curved and straight artery forceps.

- 5 mega pixel sony digital camera was used for taking photographs

METHOD OF DISSECTION

During autopsy on removal of the skull vault carefully, taking care not to damage the dura, the dura in the frontal region was incised and 15 ml of 20% formaldehyde was injected into the subdural space. After 10 minutes dura was opened transeversely and the anterior limit of falx cerebri cut. The two frontal lobes are retracted slowly and carefully to expose and cut the optic nerve and ICA entrance into the cranial cavity.

Both the cerebral hemispheres are progressively lifted after cutting cranial nerves one by one at their exit. The brain stem and basilar artery are cut at the level of tentorial hiatus. The falx cerebri posterior attachment is cut to completely remove both cerebral hemispheres. The entire specimen is soaked in 10% formaldehyde solution for about 10-15 minutes.

Further discussions are under 4x magnififcation.

The anterior inter hemisphric fissure is injected with 5 ml saline to ease dissection while opening it. The anterior interhemispheric fissure is opened by standard microneurosurgical technique.

ICA is traced to bifurcation then the ACA ,[A1-acom-A2] and its branches coursing over the medial surface of frontal lobe , over the corpus callosum and the cortical areas are carefully dissected.

The ICA at its origin is tied and injected with red poster colour solution to make the vessel prominent and to ease the dissection of perforators.

Length of Right A1 segment and Left A1 segment and ACOMA were noted. Number of ACOM arteries and its course noted.

Diameter of Rt A1 ,LA1 , ACom, Rt A2, Lt A2 noted

Site of origin of Recurrent artery of Heubner noted.

Number and location of basal perforators noted.

Branching pattern of A2 is noted

A. Com to optic chiasm and optic nerve distance noted.

Perpendicular distance from olfactory tract to ACOM noted.

ACOM artery to anterior clinoid process distance and planum sphenoidale distance noted.

OBSERVATIONS

PART A

1. Rt. A1 Outerdiameter
2. Lt. A1 Outerdiameter
3. Rt. A2 Outerdiameter
4. Lt. A2 Outerdiameter
5. ACom A Outerdiameter
6. Rt. A1 Length
7. Lt. A1 Length
8. ACom A Length
9. Rec. Artery of Heubner from A1
10. Rec. Artery of Heubner from Acom Jn.
11. Rec. Artery of Heubner from A2
12. Rec. Artery of Heubner Type 1
13. Rec. Artery of Heubner Type 2
14. Rec. Artery of Heubner Type 3
15. ACom to RHA distance
16. No. of AcomA

PART B

In addition to the measurements in PART B the relationship of artriel segment to bony landmarks and soft tissues were also studied. The number and location of perforators ,course of recurrent artery of Heubner were studied.

1. Proximal A1 perforator
2. Distal A1 Perforator
3. ACom Perforator
4. ACom to Orbito Frontal distance
5. ACom to Fronto Polar distance
6. ACom to Optic Chiasma distance
7. ACom to Olfactory Tract distance
8. ACom to Lamina terminalis distance
9. ACom to Pituitary Stalk distance
10. ACom to Ant. Cli. Process distance
11. ACom to Planum Sphenoidale distance

PART C

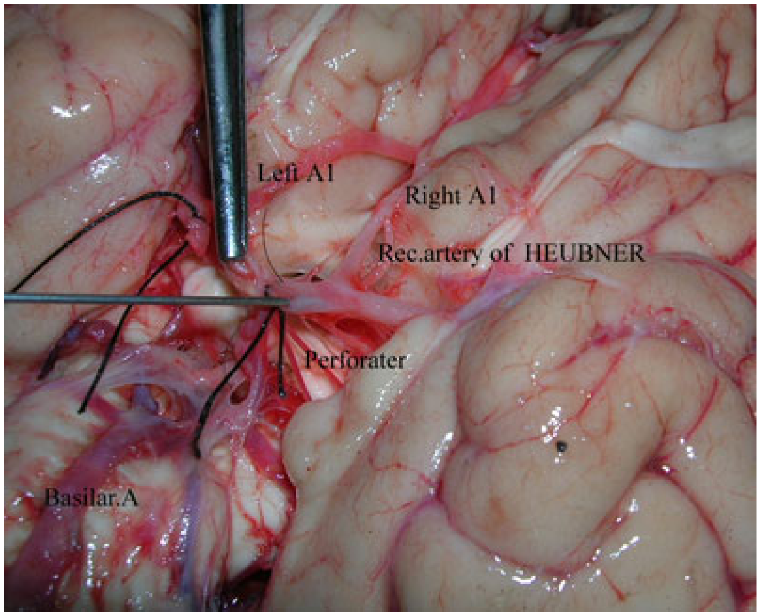
Further we also compared the data of the study with other published studies where applicable.

ABBREVATIONS USED

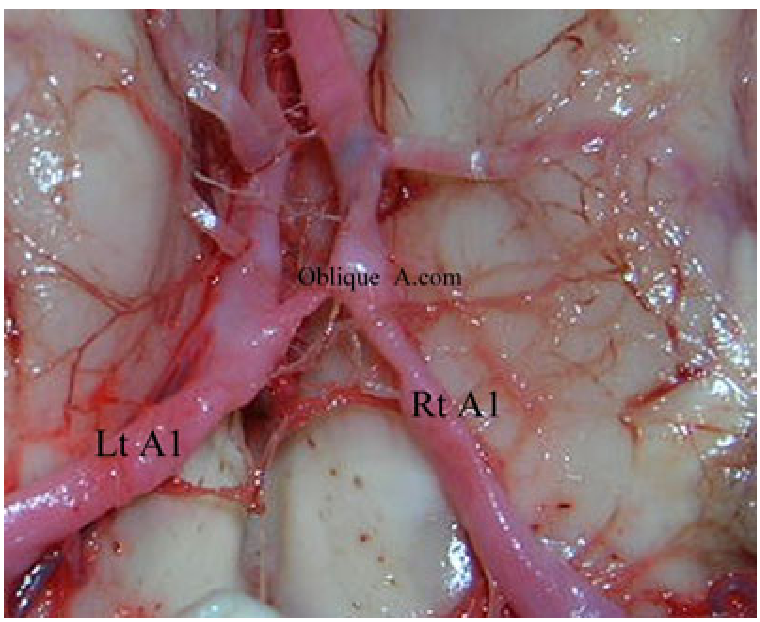
RA1OD	Rt. A1 Outerdiameter
RCSA	Rt. A1 Cross sectional area
L.A1OD	Lt. A1 Outerdiameter
LA1CSA	Lt. A1 Cross sectional area
RA2OD	Rt. A2 Outerdiameter
RA2CSA	Rt. A2 Cross sectional area
LA2OD	Lt. A2 Outerdiameter
LA2CSA	Lt. A2 Cross sectional area
AComAOD	ACom A Outerdiameter
AcomCSA	ACom A Cross sectional area
RA1L	Rt. A1 Length
LA1L	Lt. A1 Length
AComAL	ACom A Length
RAHA1	Rec. Artery of Heubner from A1
RAHAcomJn	Rec. Artery of Heubner from Acom Jn.
RAHA2	Rec. Artery of Heubner from A2
RAHI	Rec. Artery of Heubner Type 1
RAHII	Rec. Artery of Heubner Type 2
RAHIII	Rec. Artery of Heubner Type 3
RAHAcom	ACom to RHA distance
NoAcom	No. of ACom
PrA1PfA	Proximal A1 perforator
DiPfA	Distal A1 Perforator
AComPfA	ACom Perforator
OFADIS	ACom to Orbito Frontal distance
FPADIS	ACom to Fronto Polar distance
AcomOC	ACom to Optic Chiasm distance
AcomOlTr	ACom to Olfactory Tract distance
AcomLaT	ACom to Lamina terminalis distance
AcomPitS	ACom to Pitutary Stalk distance
AcomAclPr	ACom to Ant. Cli. Process distance
Acomplsp	ACom to Planum Sphenoidale distance
a1csa	Cross Sectional Area A1 (Left + Right)
a2csa	Cross Sectional Area A2 (Left + Right)
a1lt_rt	Difference in CSA of A1 (Left - Right)
a1length	Area A1
A1Pfa	Difference in length of A1 (Left - Right)
	A1 Perforator (Proximal + Distal)

A master chart was prepared including all the data collected.

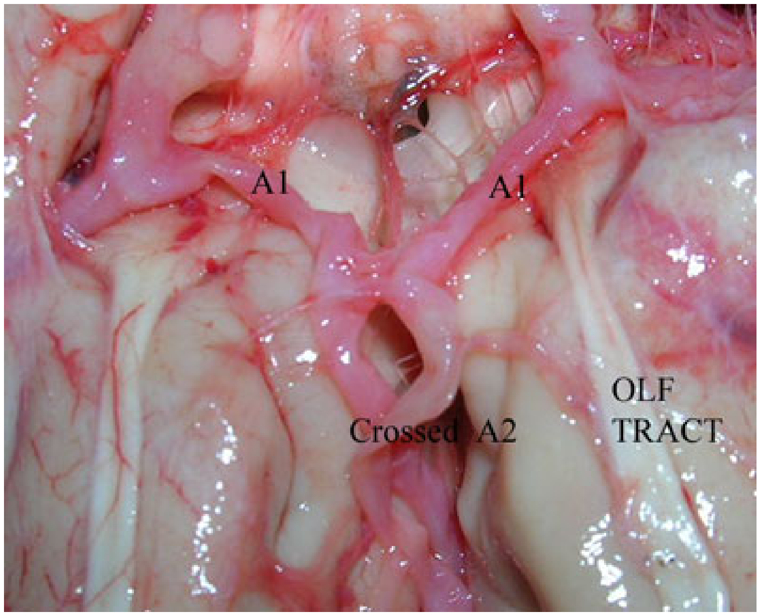
PHOTOS



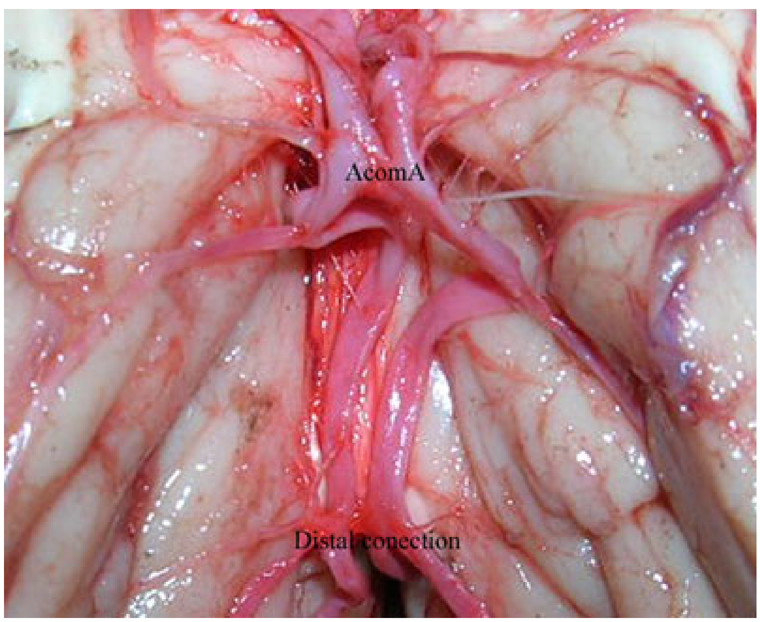
Perforator of M1 and Rec.artery of Heubner



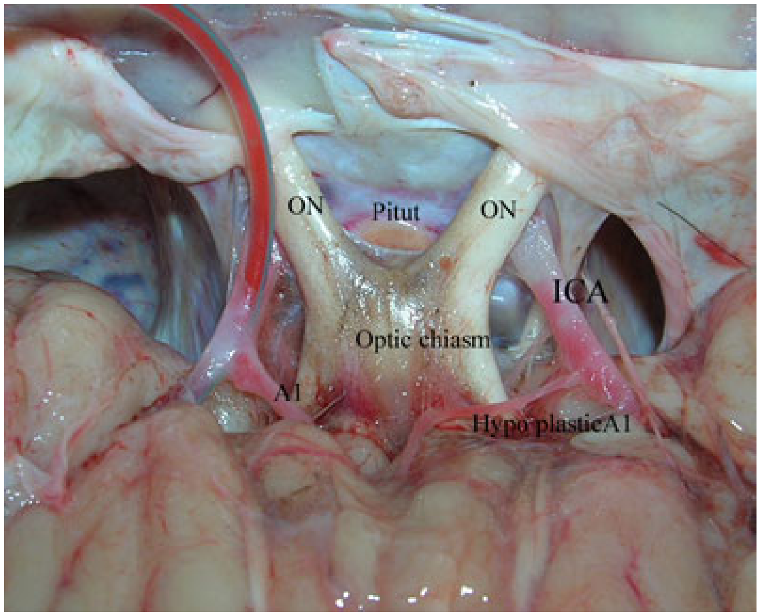
Oblique A.com Artery



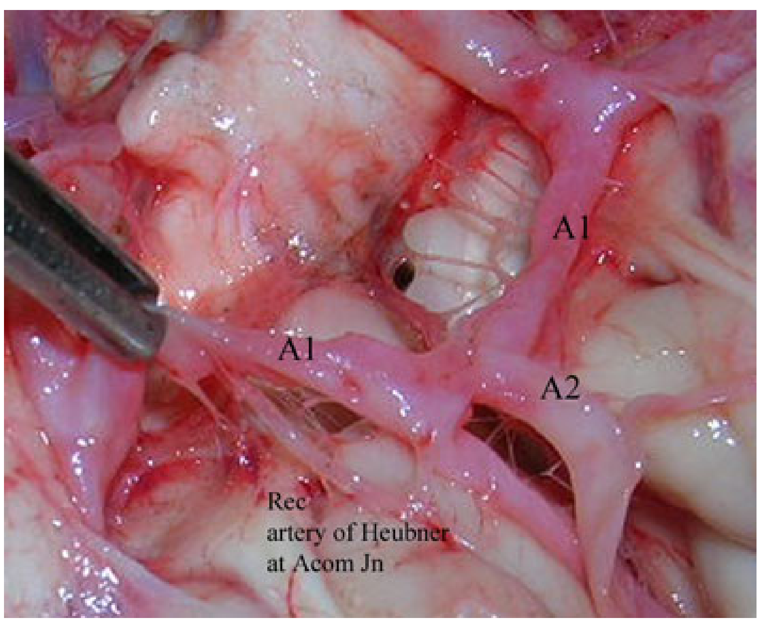
Crossed A2 Segment



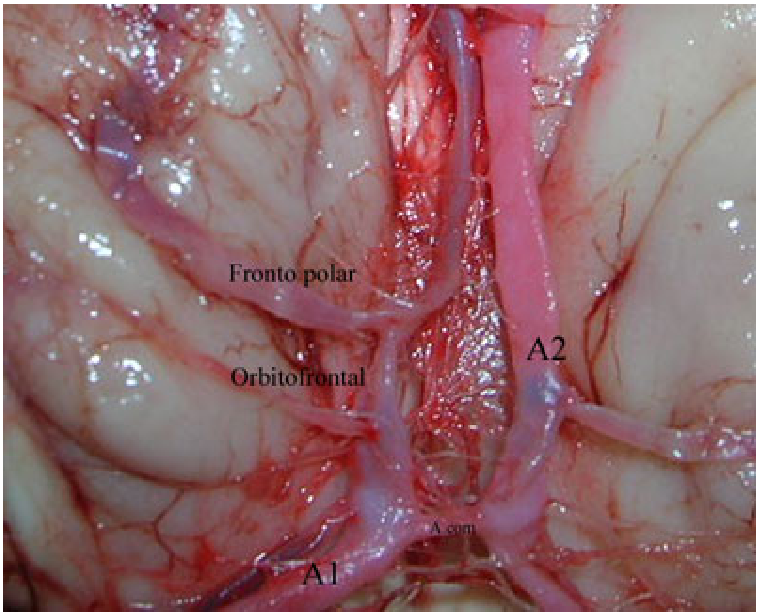
AcomA and Distal interconnection Between A2



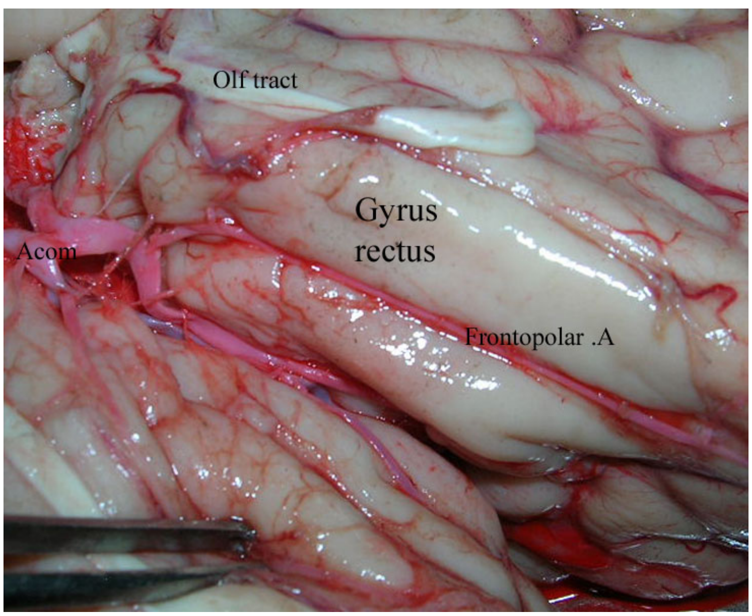
Hypoplastic A1 and the Relationship of Optic Aparatus to ACA



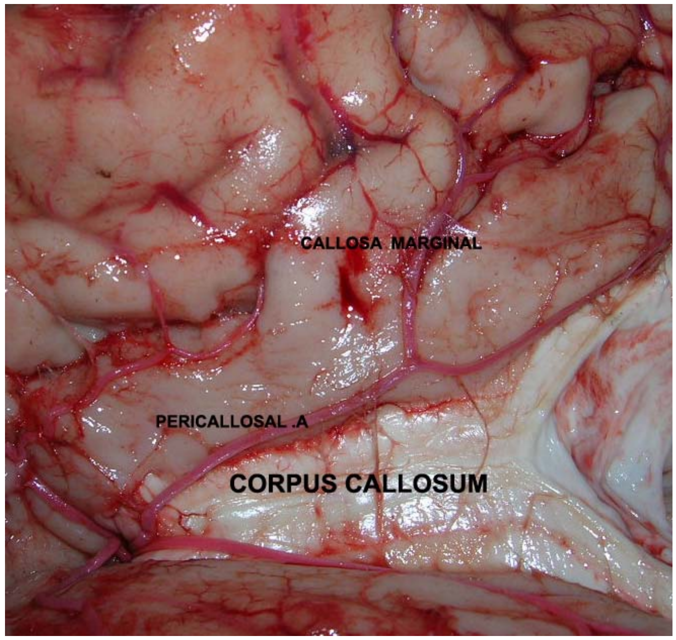
Rec. artery of Heubner at Acom Jn.



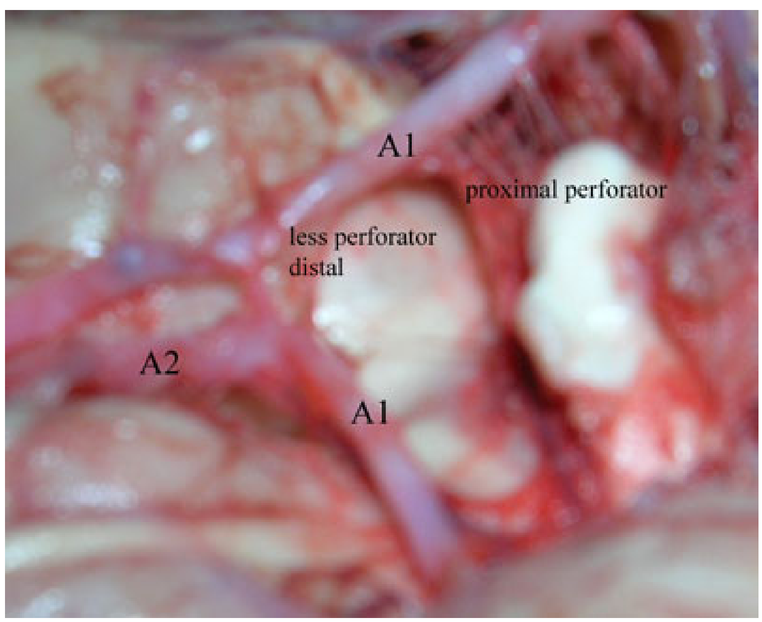
Branches of A2 Segment



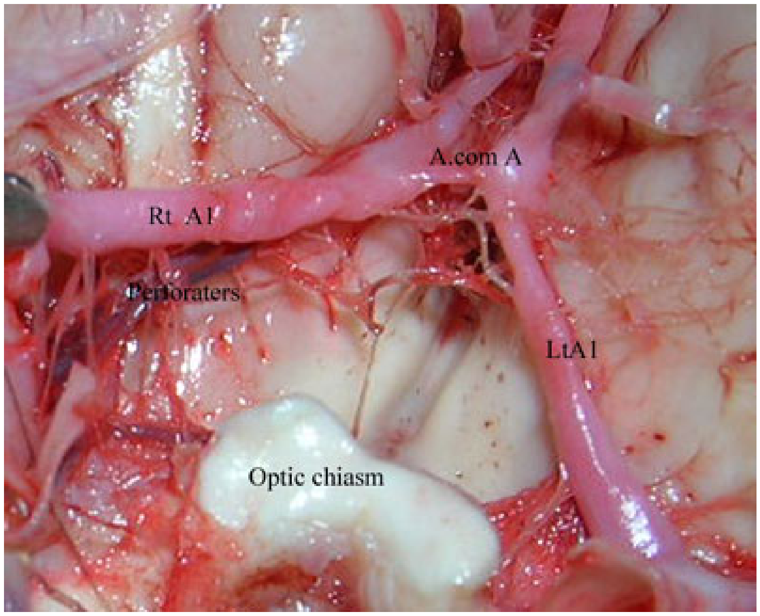
Relationship of Gyrus rectus to AcomA



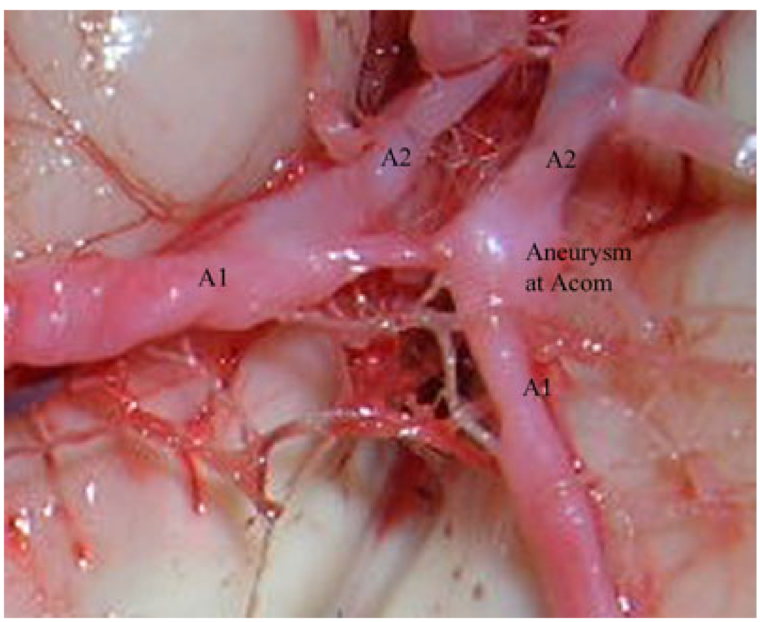
Peri Callosal and Calloso Marginal Artery



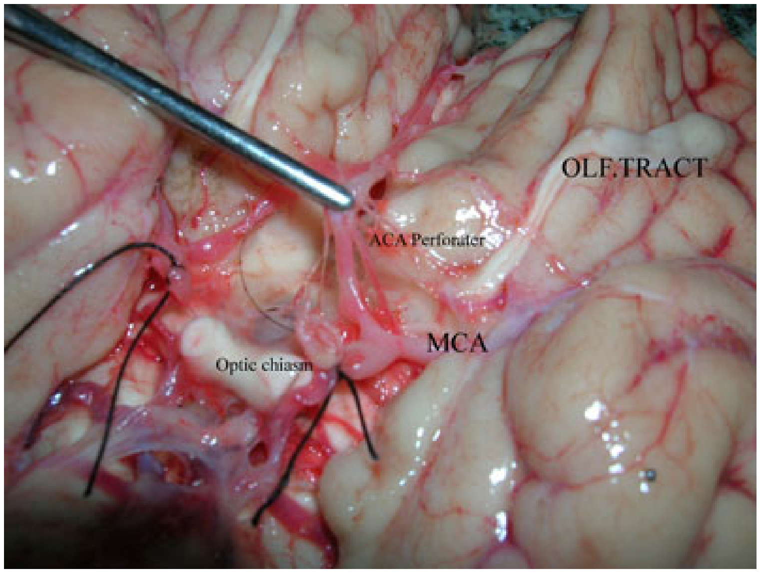
Cluster of Proximal Perforators



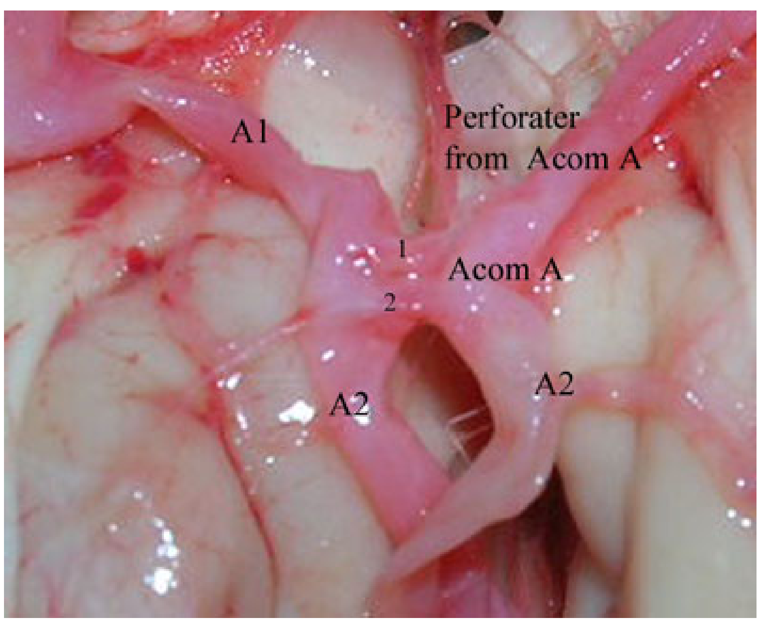
Perforators of Right A1 Segment



Aneurysm at Acom Junction



A1 Perforators and Reccurent Artery of Heubner



Duplication of AcomA

ANALYSIS OF RESULTS

The obtained data was analysed using descriptive statistics, Chi square test and student T-test .

MEASUREMENT MADE ON Rt A1

Rt.A1 Outerdiameter(Rt A1 OD)

Table : 1

Rt A1 outer diameter in mm

	N	Minimum	Maximum	Mean	SD
Rt.A1 Outerdiameter	40	1.50	3.50	2.54	0.41

The average outer diameter of Rt A1 just distal to bifurcation was 2.54mm.

The maximum outer diameter recorded was 3.5mm

The minimum outer diameter recorded was 1.5mm

Rt A1 cross sectional area(Rt A1 CSA)

Rt A1 –cross sectional area was calculated using the formula

$$\text{Rt A1 CSA} = \pi \left[\frac{\text{RA1OD}}{2}\right]^2$$

The mean cross sectional area of Rt a1 segment of anterior cerebral artery was 5.19.

MEASUREMENT MADE ON Lt A1

Lt A1 outer diameter(Lt A1)

Table : 2

Lt A1 Outer diameter in mm

	N	Minimum	Maximum	Mean	SD
Lt A1 OD	40	1	3.50	2.50	0.53

The average outer diameter Lt A1 was 2.50mm

The maximum outer diameter recorded was 3.50mm

The minimum outer diameter recorded was 1mm

Lt A1 Cross Sectional area

Lt A1 cross Sectional area was calculated using the formula

Lt A1 CSA = $\pi \left[\frac{LA1OD}{2}\right]^2$

The mean Lt A1 cross sectional area was 5.13sqmm

There is no significant difference in the Lt and Rt A1 cross sectional area.

Comparison of Rt A1 and Lt A1 length using paired sample statistics

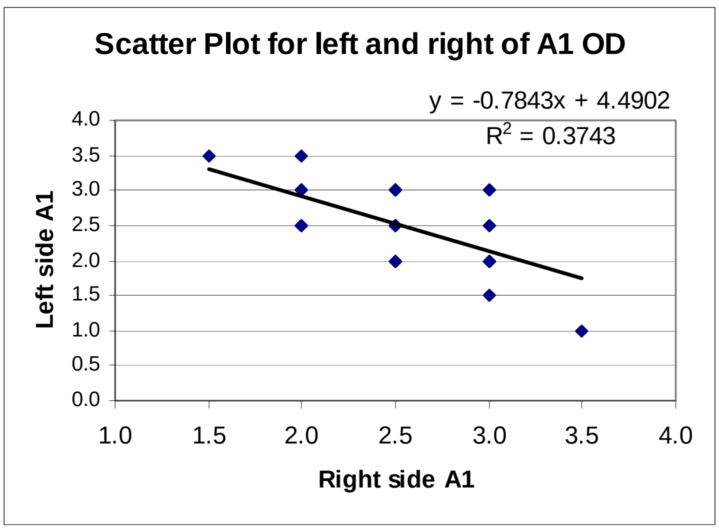
Paired Samples Statistics

Table : 3

	Mean	**SD**
Rt A1 Length	13.78	1.577
Lt A1 Length	13.75	1.498

Most Rt A1 , Lt A1 Segments of anterior cerebral artery had equal length.

COMPARISION OF RIGHT A1 AND LEFT A1 DIAMETER



There is a significant positive correlation between Rt and Lt A1 diameter when one side A1 diameter decreases in other side A1 diameter increases.

Rt and Lt A2 diameter

Table : 4

	Minimum	Maximum	Mean	SD
Rt A2	2	3.5	2.53	0.45
Lt A2	1.5	3.5	2.48	0.48

The minimum Rt A2 diameter is 2mm

The maximum Rt A2 diameter is 3.5mm

The mean Rt A2 diameter is 2.53mm

The minimum Lt A2 diameter is 1.5mm

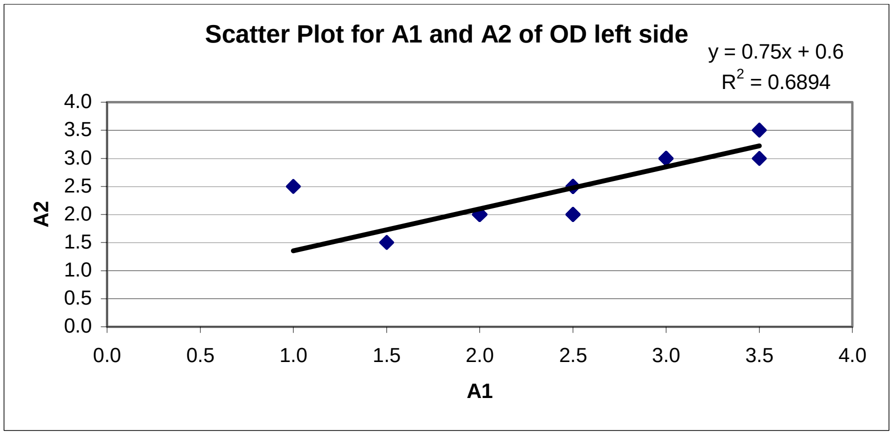
The maximum Lt A2 diameter is 3.5mm

The mean Lt A2 diameter is 2.48mm

Lt A2 mean cross sectional area 4.99

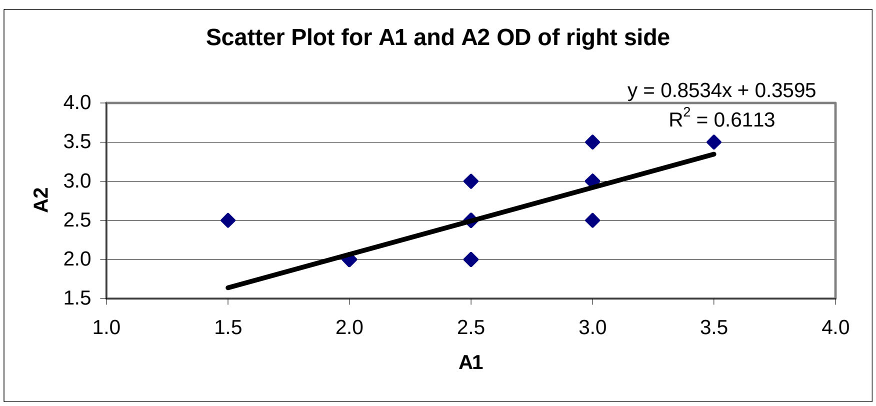
Rt A2 mean cross sectional area 5.17sqmm.

SCATTER PLOT STUDY OF A1 A2 OUTER DIAMETER ON LEFTSIDE



There is significant positive correlation between A1 outer diameter and A2 outer diameter . When the diameter of Lt A1 increases the Lt A2 diameter also increases.

SCATTER PLOT STUDY OF Rt A1 AND Rt A2 OUTER DIAMETER



There is significant positive correlation between A1 outer diameter and A2 outer diameter .When the diameter of Rt A1 increases the Rt A2 diameter also increases.

MEASUREMENTS OF ACOM

Table : 5

ACom outer diameter and cross sectional area

	Minimum	Maximum	Mean	SD
Outer diameter	1	2.50	1.33	0.46
Cross sectional area	0.79	4.91	1.54	1.19

The minimum outer diameter of AcomA is 1mm

The maximum outer diameter of AcomA is 2.5mm.

The mean outer diameter of AcomA is 1.33mm .

The minimum cross sectional of AcomA is 0.79sqmm**.**

The maximum cross sectional area is 4.91sqmm.

The mean cross sectional area is 1.54sqmm.

Table : 6

Number of ACom

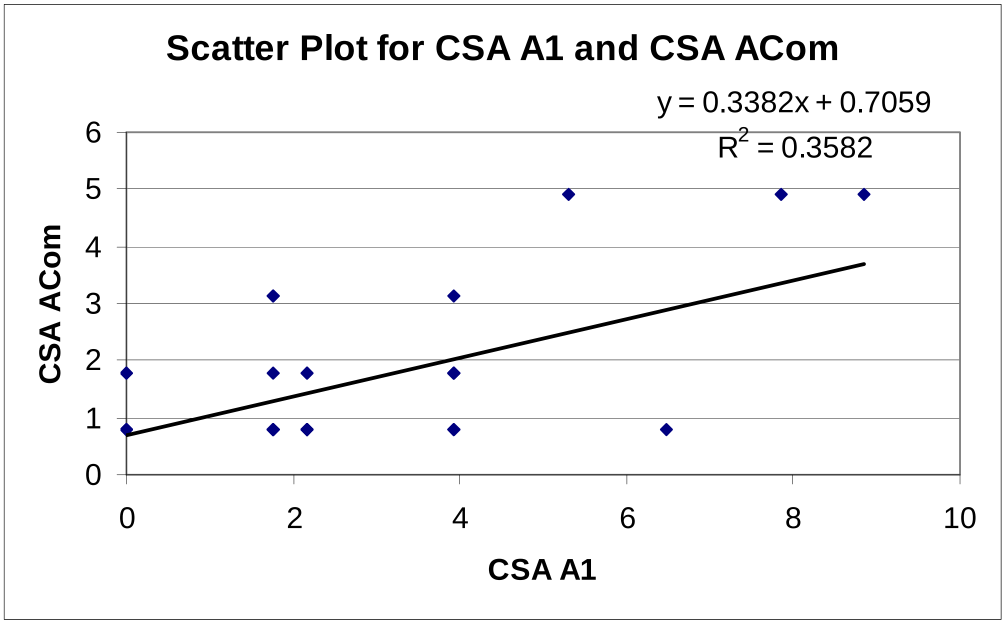
	Frequency	Percent
One	32	80
Two	7	17.5
Three	1	2.5

There is one Acom in 80% of the brain

There is Two AComs in 17.5% of the brain

There is Three Acoms in 2.5% of the brain

Scatter plot study2



There is significant positive correlation between Acom cross sectional area and difference in A1 cross sectional area. When the difference in the cross sectional areas of Rt and Lt A1 increases the Acom cross sectional area also proportionatly increases.

Cross sectional area comparison of A1 and A2 segments on both sides using paired sample statistics. Paired Samples Statistics

Table : 7

Cross Sectional Area Comparison

	Mean	**SD**
Cross Sectional Area A1(Left+right)	10.3174	1.69091
Cross Sectional Area A2 (Left + Right)	10.1554	2.27043

There is not much of difference between total cross sectional areas of A1(left + Right) and A2 (Left + Right**)**

The origin of Rec. Artery of Heubner

Table : 8

	Frequency	Percent
From A1	5	12.5
From Acom Jn	9	22.5
From A2	26	65.0

65 % of Rec.Artery of Heubner arises from A2

22% of Rec.Artery of Heubner arises from Acom Jn

12% of Rec.artery of Heubner arises from A2

Table : 9

Course of Rec.Artery Heubner

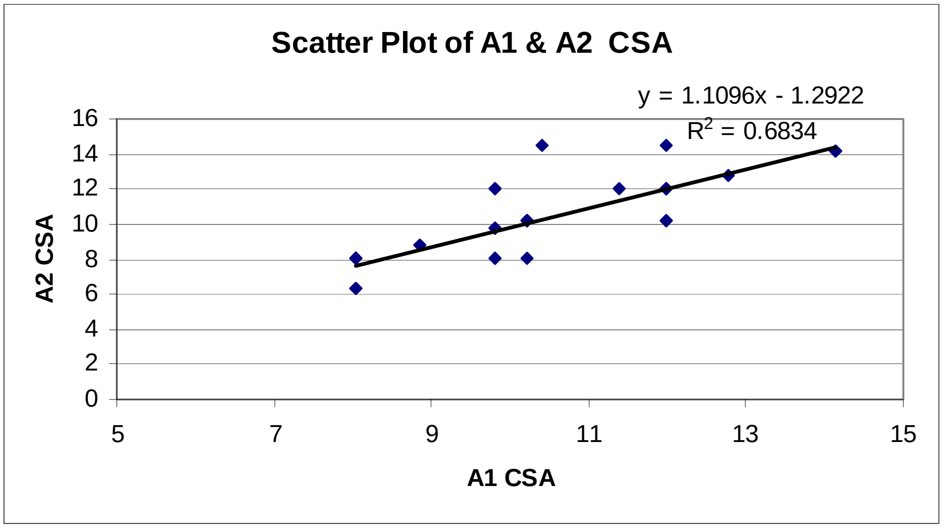
	Frequency	Percent
Type 1	25	62.5
Type 2	13	32.5
Type 3	2	5

62 % of Rec.Artery of Heubner runs in superier course to A1

32 % of Rec.Artery of Heubner runs in anterior course to A1

5 % of Rec.Artery of Heubner Runs in posterior course to A1

Scatter plot study1

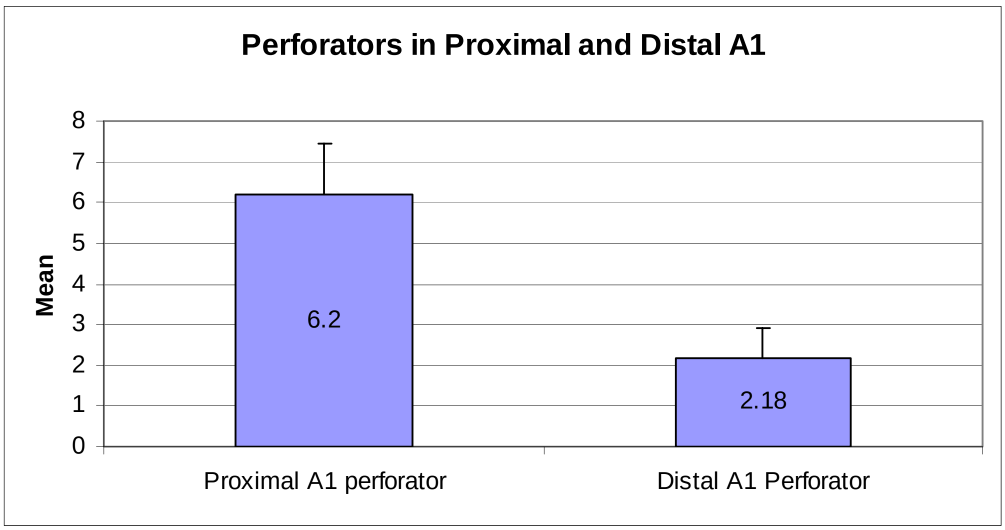


Scatter plot source significant positive relationship between total A1 and total A2 CSA . when total A1 cross sectional area increases total A2 cross sectional area also increases.

PART B

The relationship of arterial segment to bony landmarks and soft issues and the number and pattern of the vessels**.**

NUMBER OF PERFORATORS IN PROXIMAL AND DISTAL A1

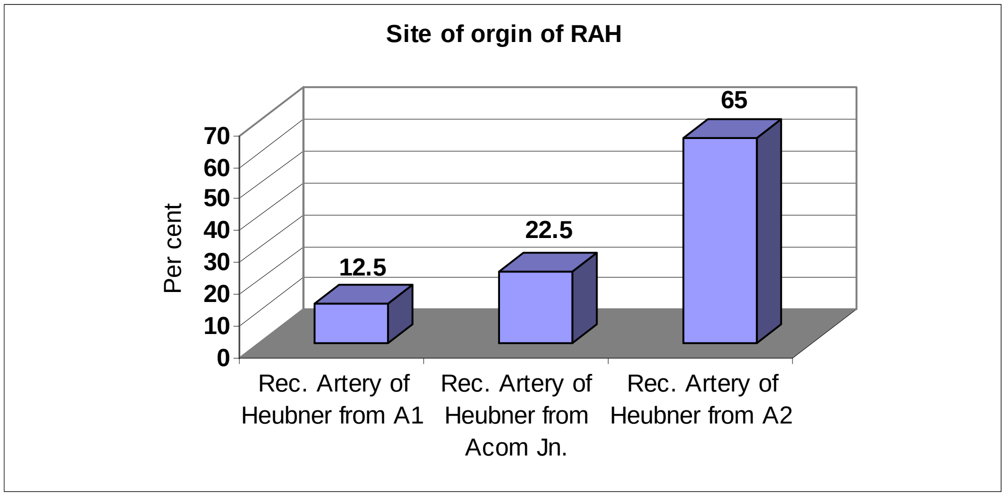


The mean perforators in Proximal segment of A1 6.2

The mean perforators in distal segment of A1 2.18

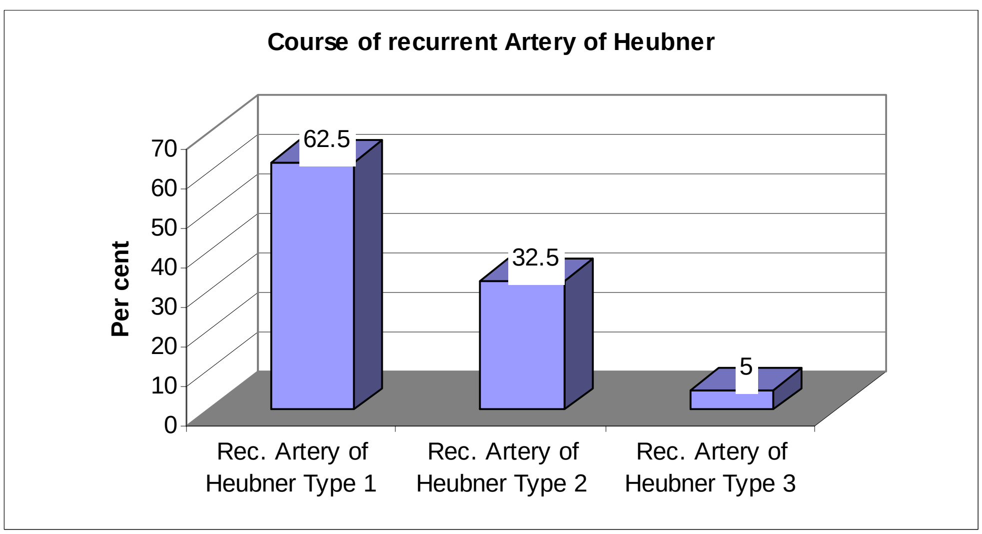
So maximum number of perforators arise from proximal segment.

Site of orgin of Rec.Artery of Heubner



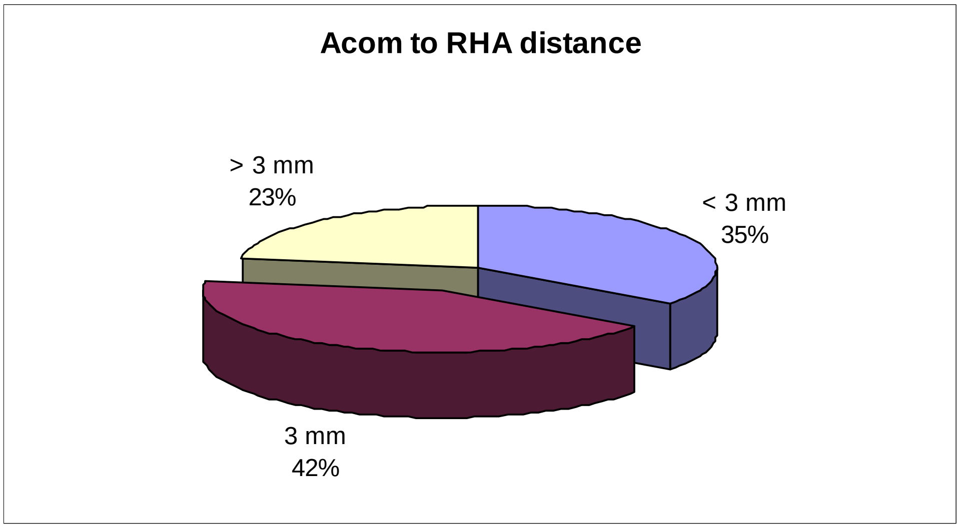
Most of the Heubner artery rises from A2.

Course of the Recurrent Artery Heubner



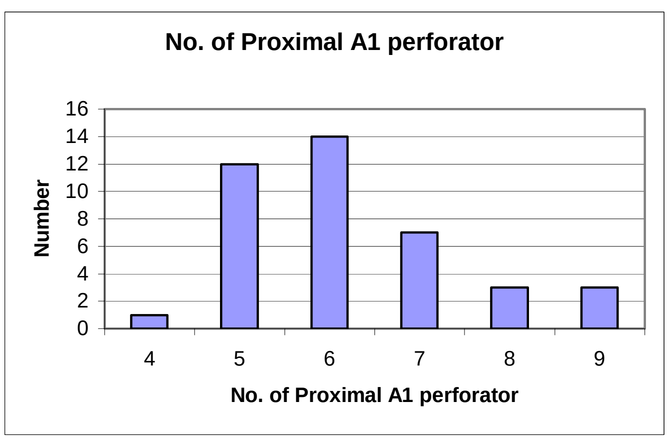
Most of the recurrent artery of the Heubner runs in the superior course.

ACom to Recurrent Artery of Heubner distance



77% of the recurrent of the Heubner arises with in the 3mm distance from ACom.

NUMBER OF PROXIMAL A1 PERFORATOR



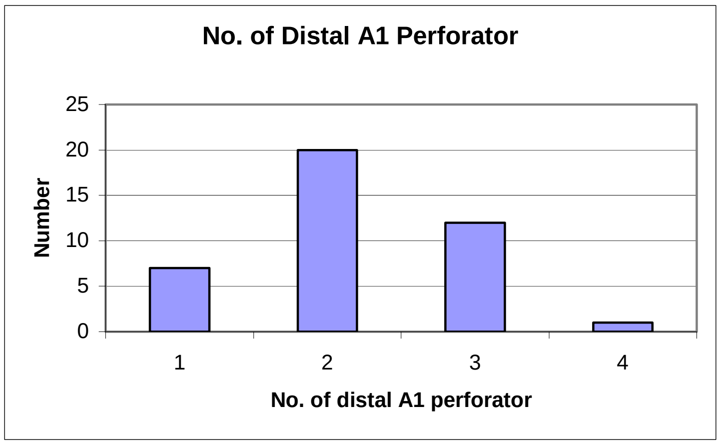
Number of proximal ACom perforator varies from 4 to 9 the mean ACom perforator is 6.20.

NUMBER OF PROXIMAL A1 PERFORATOR

Table : 10

	Minimum	Maximum
Number of proximal perforator	4	9

NUMBER OF DISTAL PERFORATOR OF A1

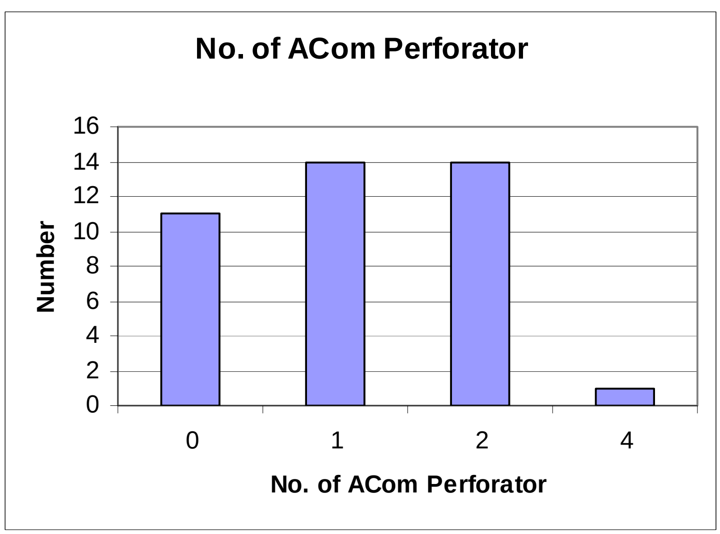


The minimum distal A1 perforator is 1mm

The maximum distal A1 perforator is 4mm

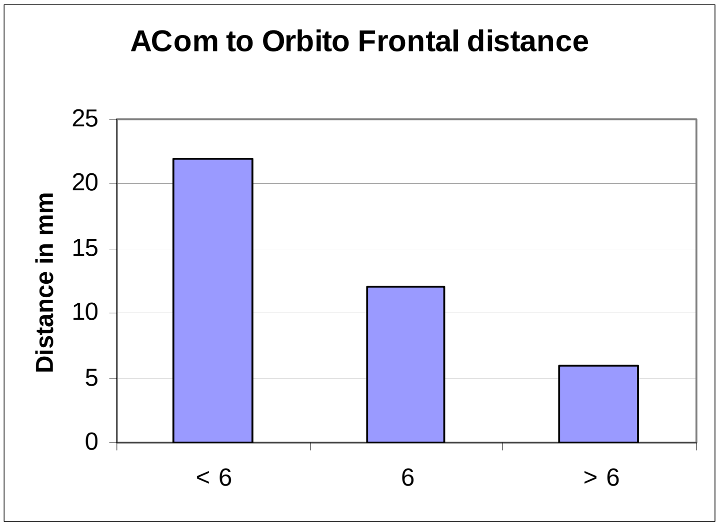
The mean distal A1 perforator is 2.18mm

NUMBER OF ACOM PERFORATOR



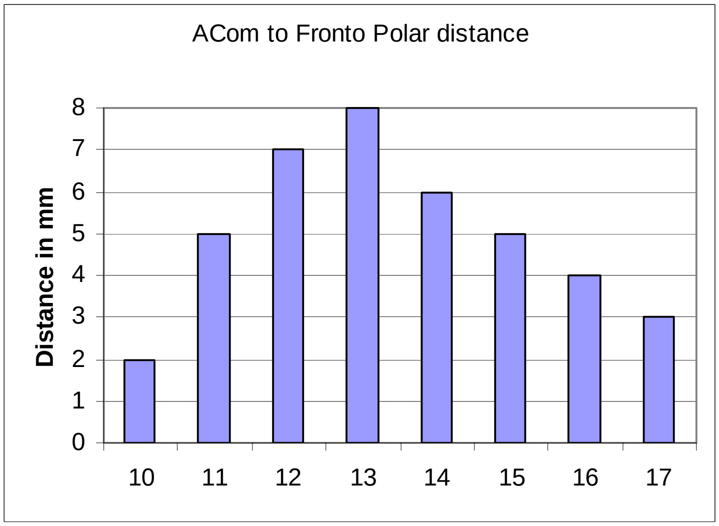
Number ACom perforater is from 0 to 4

ACOM TO ORBITOFRONTAL ARTERY DISTANCE



Most of the orbito frontal artery arises within 6mm from ACom junction.

ACOM TO FRONTO POLAR ARTERY DISTANCE

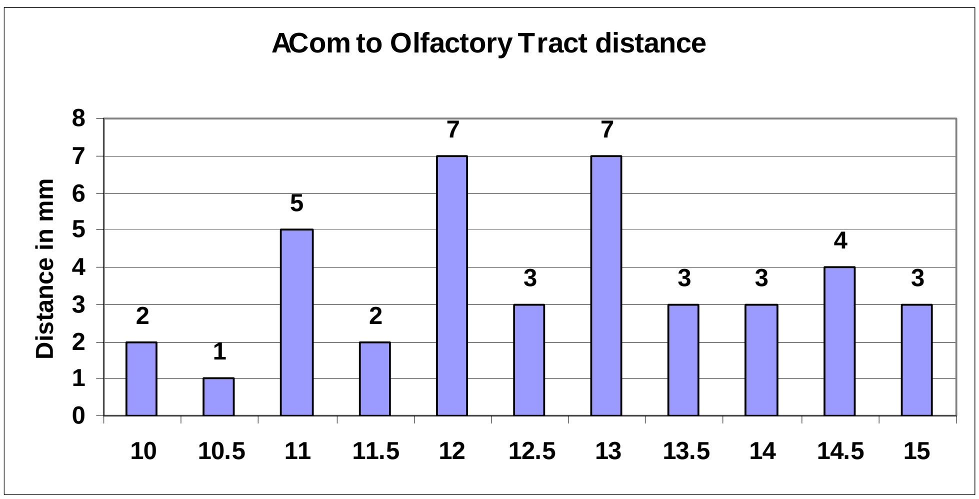


Most of the frontopolar artery arises from 13.43mm from ACom junction.

ACom to olfactory tract distance

	minimum	maximum	mean	SD
ACom to olfactory tract distance	10	15	12.66	1.40

The mean distance from Acom to olfactory tract is 12.66 mm



ACOM TO OPTIC CHIASM DISTANCE

Table :11

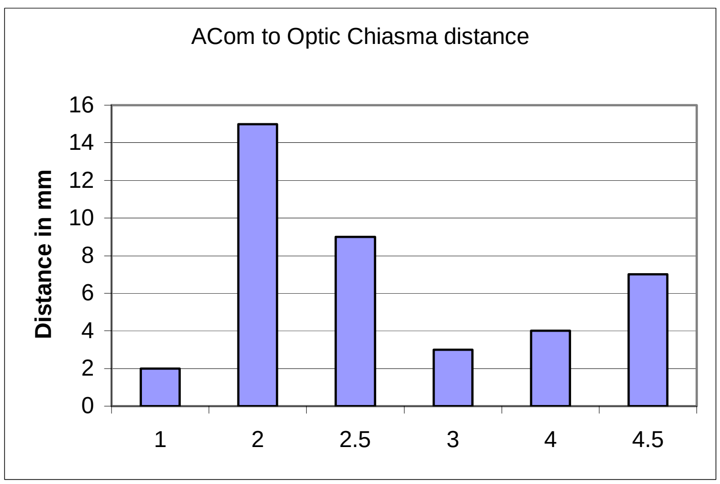
	Minimum	Maximum	Mean	SD
ACom to Optic Chiasma distance	1	4.5	2.78	1.05

The minimum Acom to optic chiasm distance is 1 mm

The Maximum Acom to optic chiasm distance is 4.5 mm

The mean ACom to optic chiasm distance is 2.78 mm.

ACom to Optic Chiasma Distance



Most of the patient ACom to optic chiasm distance is 2 mm.

ACOM TO LAMINA TERMINALIS DISTANCE

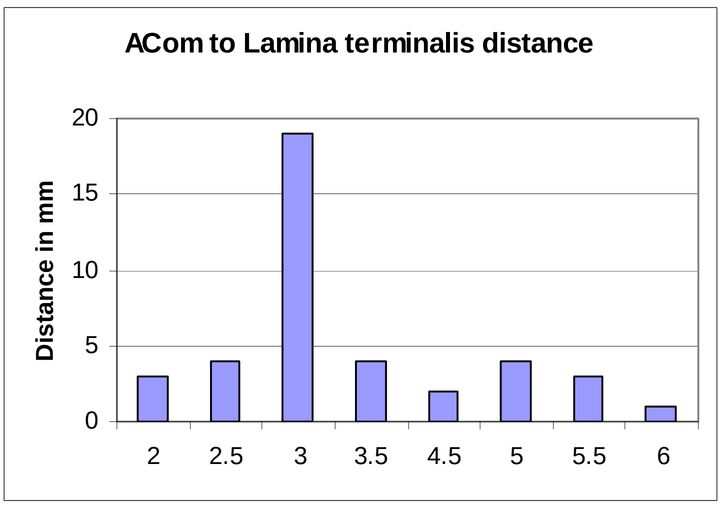
Table : 12

	Minimum	Maximum	Mean	SD
ACom to lamina Terminalis	2	6	3.46	1.07

The Minimum distance of lamina terminalis from Acom is 2 mm.

The Maximum distance of lamina terminalis from Acom is 6 mm

The mean distance of lamina terminalis ACom artery is 3.46mm.



In most of the brains ACom is 3mm from lamina terminalis .

ACOM TO PITUITARY STALK DISTANCE

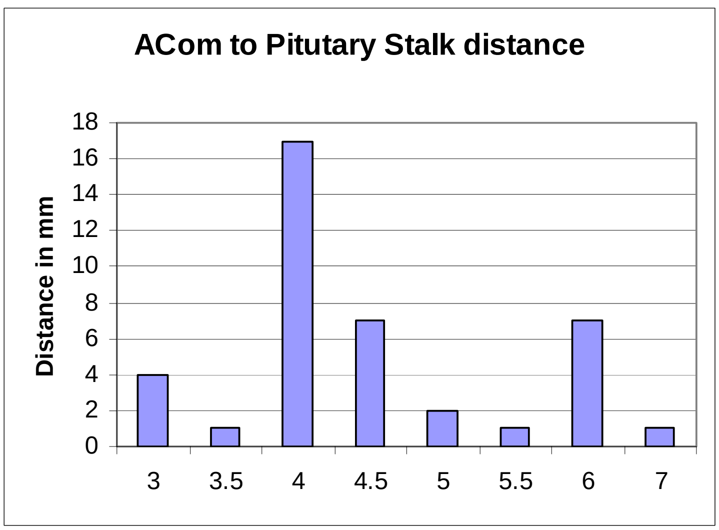
Table : 13

	Minimum	Maximum	Mean	SD
Acom to pituitary stalk distance	3	7	4.49	0.98

The Minimum Acom to pituitary stalk distance is 3 mm

The Maximum Acom to pituitary stalk distance is 7 mm

The mean ACom to pituitary stalk distance is 4.49mm.



DISTANCE OF ACOM TO ANTERIOR CLINOID PROCESS

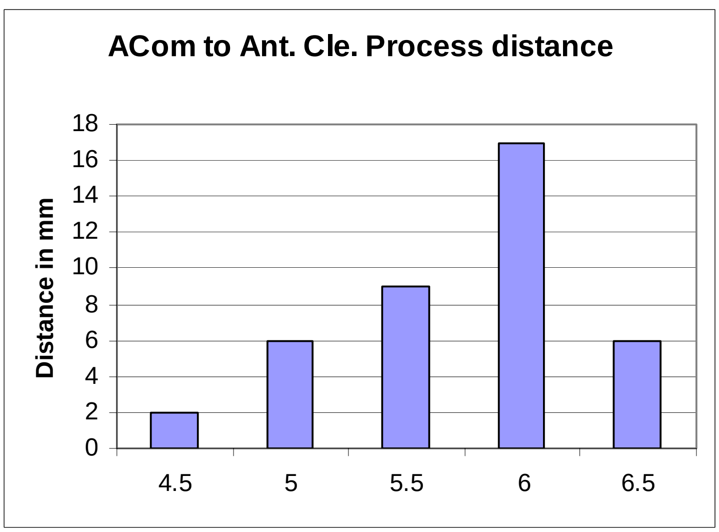
Table : 14

	Minimum	**Maximum**	**Mean**	**SD**
Distance of ACom to anterior clinoid process	4.50	6.50	5.74	0.54

The minimum distance of Acom to anterior clinoid process 4.5 mm

The maximum distance of Acom to anterior clinoid process 6.4 mm

The mean distance of ACom to anterior clinoid process is 5.74mm.



ACOM TO PLANUM SPHENOIDAL DISTANCE

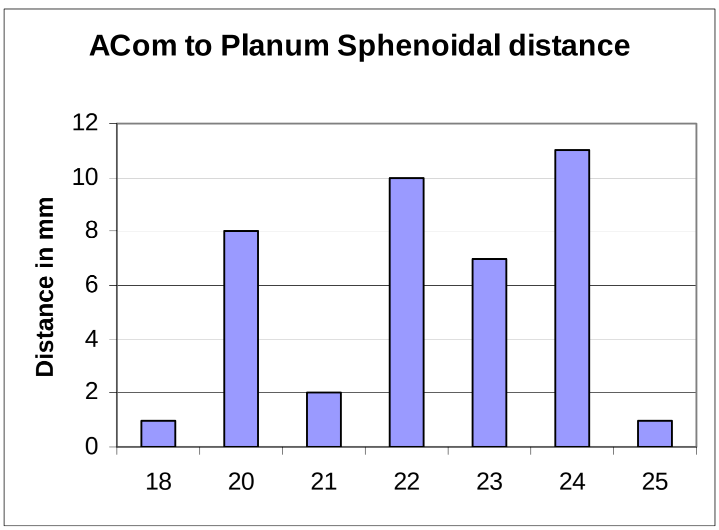
Table : 15

	Minimum	**Maximum**	**Mean**	**SD**
ACom to planum sphenoidal distance	18	25	22.5	1.66

The minimum Acom to planum sphenoidale distance is 18 mm

The maximum Acom to planum sphenoidale distance is 25 mm

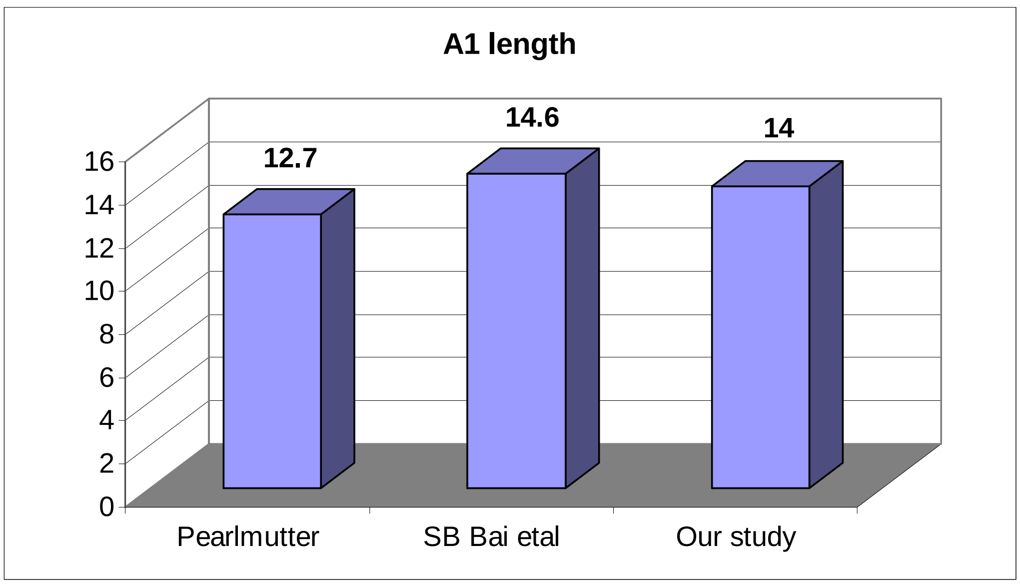
The mean of ACom to planum sphenoidale distance is 22.5 mm.



COMPARISON OF DATA

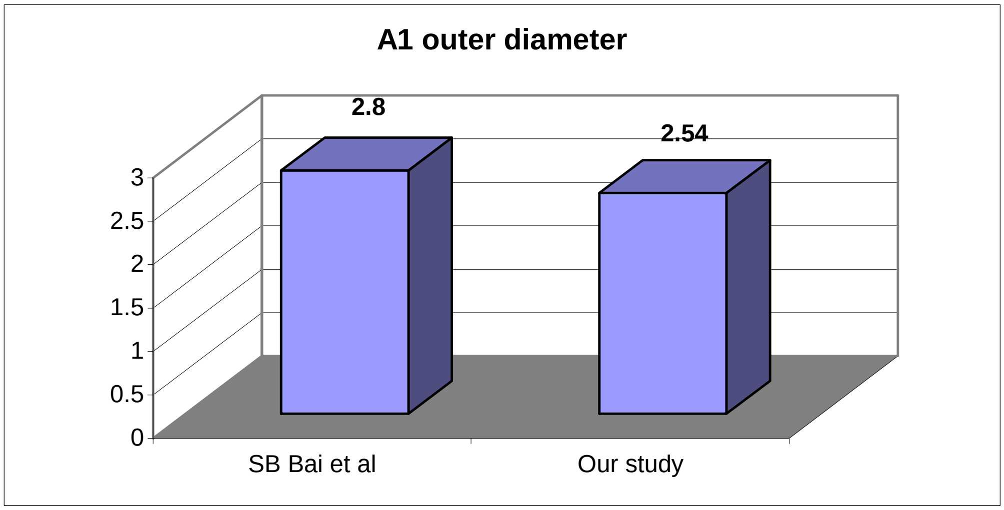
The present study of microsurgical anatomy of A1 – ACom-A2 arterial complex of our population add some significant difference when compared with similar studies in literature done on western population and other regions of Indian population.

COMPARISION OF A1 LENGTH



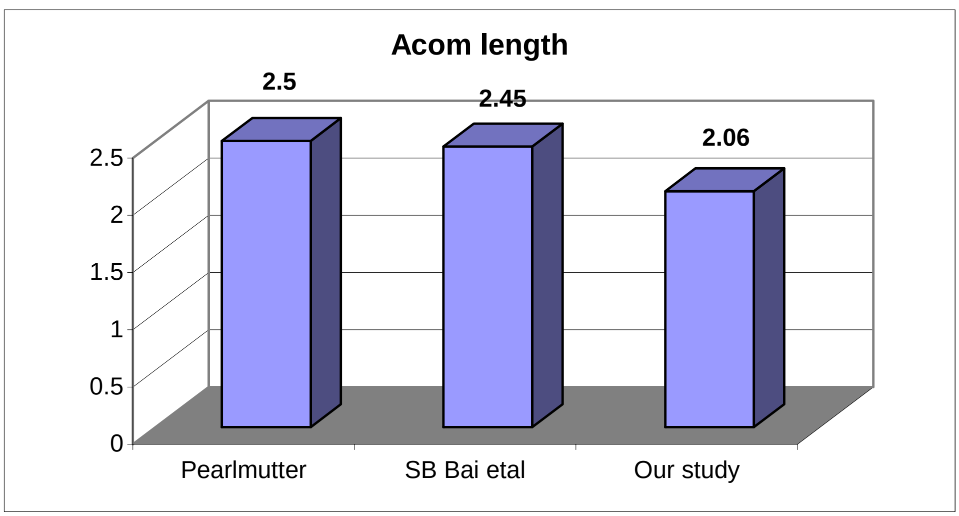
The length of A1 was comparatively larger in the present study when compared to the western population. The difference is minimal when compared to the other Indian study(SB Bai et al study).

A1 Outer Diameter



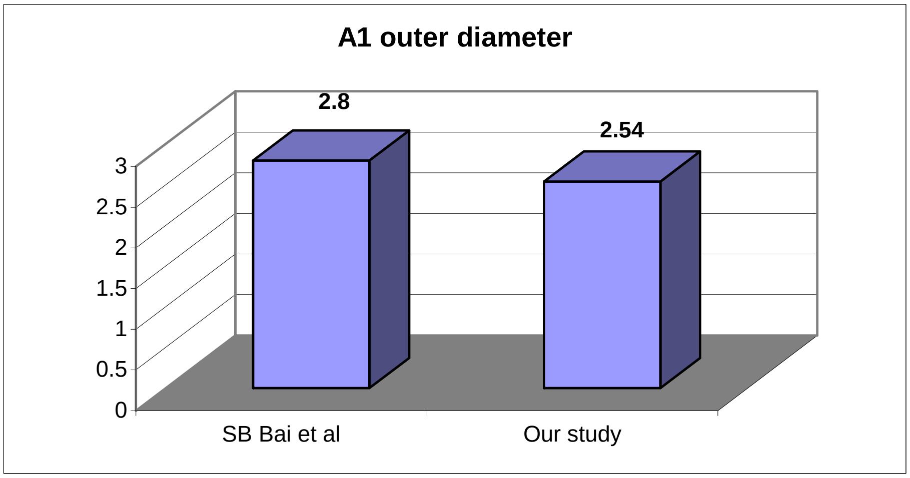
The outer diameter is almost equal when compared SB Bai et al study.

ACom Length

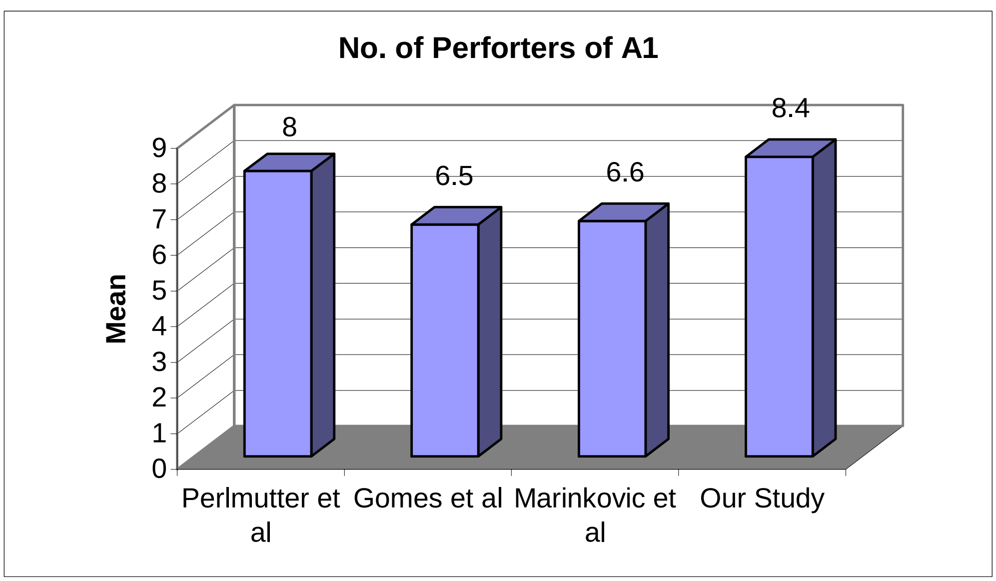


The Acom length is slightly short when compared to other studies.

ACom Outer diameter

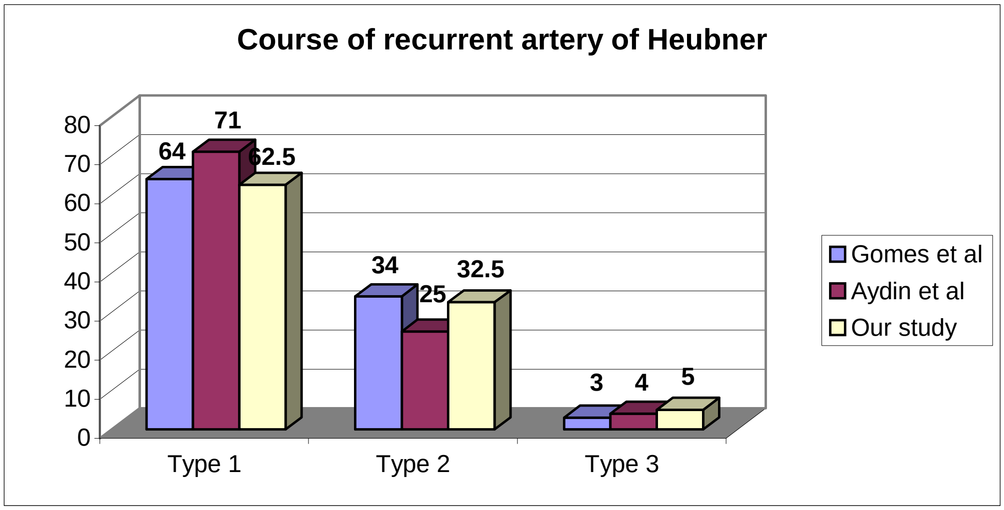


The Acom outer diameter is slightly less when compared SB Bai et al study.



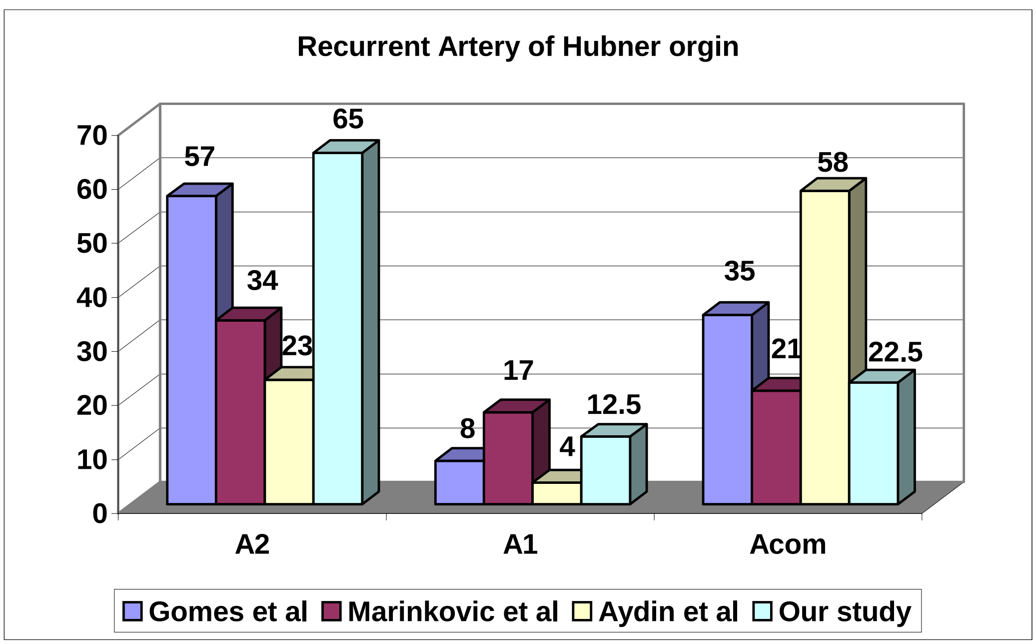
The number of perforators was around eight comparatively closer to Perlmutter et al study.

Course of Recurrent Artery Heubner



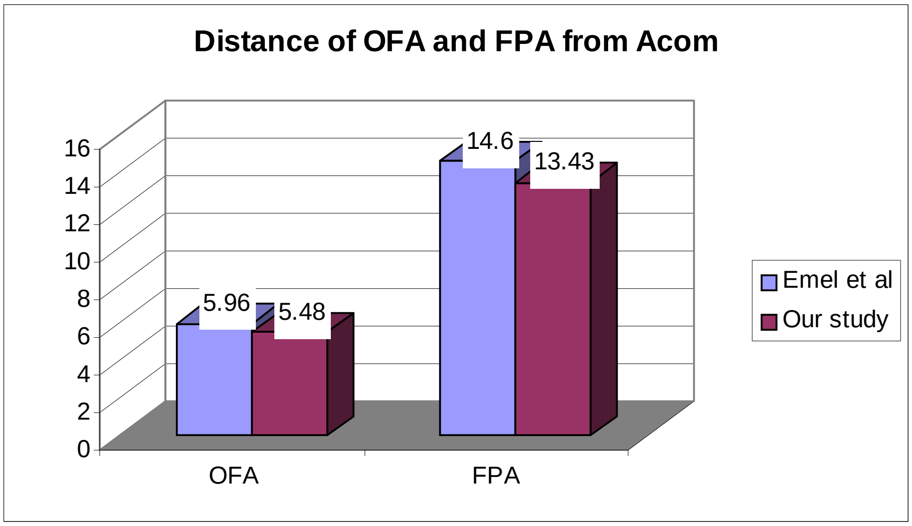
As in other studies most of the Recurrent artery of Heubner runs in the superior course.

Recurrent Artery Heubner orgin



Most of the RAH arises from A2. It is relatively closer with Gomes et al study. As in other studies less number of RHA arises from A1.

Distance of OFA and FPA from Acom



The Distance of orbito fronatal Artery and Fronta Polar Artery from Acom is Close to Emel et al Study.

DISCUSSION

Based on the observations of the present study, the significance are discussed on

1. Anatomical perspective
2. Pathophysiological perspective
3. Neurosurgical perspective

Anatomical perspective

- Most of the A1 anterior communicating artery junction lies over the optic chiasm; when the A1 segment is longer it lies over the optic nerves;when it is shorter it lies over the optic chiasm; This finding is in concurrence with Rhoton study.

- A1 diameter less than 1.5mm is very rare .when it is lessthan 1.5mm then it is called hypoplastic . 5% of A1were hypoplastic in our study.

- A1 length disparity is very rare. In one case in our study has disparity in diameter and in one case there was aneurysm.

- The combined cross sectional area of vessels proximal and distal to AcomA is equal. Most of the perforators from A1 arises from the proximal segment of the A1.

- Multiple perforating branches of Acom arise from posterosuperior surface. This is in agreement with the findings of the post microsurgical era studies. We had 40% of multiple perforators.

- Anterior communicating artery formed from coalescence of an embryological multichannel plexes. So fenestration and duplication of the vessels is seen. We had 7.5% of this variation in our study.

- Two proximal A2 segment do not run in the same coronal plane it may lie one over the other as in our study. It was also described by other studies.

- Most of the recurrent artery of the Heubner arises from A2 segment and also most of them from intial 3mm of A2.

- RAH runs in the superior course to A1 in 50% of brain.

- Recurrent artery of the Heubner arises from lateral aspect of the parent vessel.

- The first branch is the orbito frontal which arises from the intial 6mm of A2 and it is smallest branch.

- The second branch is frontopolar artery which arises within 14mm of the A2 segment.

PATHOPSYSIOLOGICAL PERSPECTIVE

- The combined cross sectional area of vessels proximal and distal to AcomA is equal (The combined cross sectional area of Rt and Lt A1 is almost equal with the combined cross sectional area of Rt and Lt A2).This cross sectional area has not been analysed by any of the previous studies. This is significant because its shows natural adaptation to compensate for hypoplasia in any one branch of the **H**(A1 –Acom-A2 Complex).

- AComA cross sectional area increases when there is hypoplasia of any one of the H limb .This favours the cross circulation between right and left side

- Hypoplastic A1 segment is associated with aneurysm at the junction of A1 with Acom artery.

- Anterior communicating artery perforators supply the laminaterminalis, hypothalamus , optic chiasm and septal nucleas.With occlusion of this vessels may lead on to unconsciousness , memory disturbances and visual deficit.

- Recurrent artery of Heubner supply anterior limb of the internal capsules, anterior striatul and nucleas accumbens Occlusion of this vessels leads to weakness of upperlimb and face and emotional disturbances.

- When compared to MCA A1 arieses at an angle from ICA. So the territory supplied by the ACA likely to suffer from hypotension-more often and earlier than MCA. This effect is compensated by nature to some extend by ACom artery and its duplication as well as by equal total cross sectional area of Rt A1+Lt A1 and Rt A2 + Lt A2.

NEUROSURGICAL PERSPECTIVE

- In view of multiple anatomic variations in the A1-ACom-A2 complex region and in view of important perforators supplying the vital structures detailed angiographic evaluation is mandatory to get the mental three dimensional vision of A1 ACom A2 complex and to know the direction of dome of the aneurysm and to know the dominant A1.

- Cautious inspection for recurrent artery of Heubner is essential because most of the RAH runs through superior course and maybe adherent to the A1 segment.

- Irrespective of the length of A1 it is not freely mobile as the tie of the perforator which hampered the mobility.

- Most of the A1 perforators arises from the proximal segment of A1 so temporary clipping may be safely applied on distal A1.

- If the recurrent artery of Heubner arises from A1 segment least likely to be damaged during ACom Anurysmal Surgery.

- In the transcallosal approach the position of A2 segment is variable. But it can be mobilised on either side.

- It is usually safer to enter lamina terminalis cistern through subpial resection of gyrus rectus.

- During surgical approach to supra chiasmatic region A1 ACom junction in encountered at a distance of 12.66 mm from olfactory tract and at a ditance of 2.78 mm from optic chiasm.

- Important structure like pituitary stack is as a distance of 4.49 mm from A1 ACom junction.

- During surgical approach tosupra chiasmatic region the A1 is reached at a distance of 5.74 mm from anterior Clinoid process.

- AComA has important and vital perforators which have to be protected by taking every precaution and if necessay by using fenestrated clips while clipping ACom aneurysm.

CONCLUSION

1. The combined cross sectional area of vessels proximal and distal to AComA is almost equal. Hypoplasia of one A1 segment is associated with large contra lateral A1.It leads to ACom aneurysm in the large A1 ACom junction.

2. A1 perforators are clustered more in A1 proximal segment. So It is better to avoid temporary clipping in proximal segment.

3. AComA also has important perforator most of them run in the postero superior direction. So these vessels must be preserved in AComA aneurysmal clipping by using fenestrated clip if necessary.

4. Most of the Recurrent artery of Heubner arise from A2 and follows the superior course to A1 even though it may not be encountered in basal approach, It is essential to identify and safeguard in other variations.

5. Orbitofrontal, Frontopolar, Rec. artery of Heubner arises from A. com A junction. These vessels can be identified by their course and destination and then the measurements of distance of each vessel from A.com gives clue to localize the ACom A.

6. Important neural structures like optic nerve, optic chiasm, pituitary stalk hypothalamus are near to AComA. Identification of these structures prevent unwanted complications.

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OBSERVATION CHART

Microsurgical Anatomy Of Anterior Cerebral Artery

A1-Acom-A2 Complex

Age: Sex :

Observation :

1.	Rt. A1 OD	:
2.	Lt. A1 OD	:
3.	Rt. A2 OD	:
4.	Lt. A2 OD	:
5.	ACom A OD	:
6.	Rt. A1 Length	:
7.	Lt. A1 Length	:
8.	ACom A Length	:
9.	Rec. Artery of Heubner from A1	:
10.	Rec. Artery of Heubner from Acom Jn.	:
11.	Rec. Artery of Heubner from A2	:
12.	Rec. Artery of Heubner Type 1	:
13.	Rec. Artery of Heubner Type 2	:
14.	Rec. Artery of Heubner Type 3	:
15.	ACom to RHA distance	:
16.	No. of ACom	:
17.	Proximal A1 perforators	:
18.	Distal A1 Perforators	:
19.	ACom Perforator	:
20.	ACom to Orbito Frontal distance	:
21.	ACom to Fronto Polar distance	:
22.	ACom to Optic Chiasma distance	:
23.	ACom to Olfactory Tract distance	:
24.	ACom to Lamina terminalis distance	:
25.	ACom to Pituitary Stalk distance	:
26.	ACom to Ant. Cli. Process distance	: